Oracle® XML DB

Developer's Guide

12*c* Release 1 (12.1)

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This manual describes Oracle XML DB. It includes guidelines and examples for storing, generating, accessing, searching, validating, transforming, evolving, and indexing XML data in Oracle Database.

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Oracle XML DB Developer's Guide, 12*c* Release 1 (12.1)

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Preface

This manual describes Oracle XML DB, and how you can use it to store, generate, manipulate, manage, and query XML data in the database.

After introducing you to the heart of Oracle XML DB, namely the `XMLType` framework and Oracle XML DB Repository, the manual provides a brief introduction to design criteria to consider when planning your Oracle XML DB application. It provides examples of how and where you can use Oracle XML DB.

The manual then describes ways you can store and retrieve XML data using Oracle XML DB, APIs for manipulating `XMLType` data, and ways you can view, generate, transform, and search on existing XML data. The remainder of the manual discusses how to use Oracle XML DB Repository, including versioning and security, how to access and manipulate repository resources using protocols, SQL, PL/SQL, or Java, and how to manage your Oracle XML DB application using Oracle Enterprise Manager. It also introduces you to XML messaging and Oracle Streams Advanced Queuing `XMLType` support.

This Preface contains these topics:

Audience

Oracle XML DB Developer's Guide is intended for developers building XML Oracle Database applications.

An understanding of XML, XML Schema, XQuery, XPath, and XSL is helpful when using this manual.

Many examples provided here are in SQL, PL/SQL, Java, or C. A working knowledge of one of these languages is presumed.

Documentation Accessibility

For information about Oracle's commitment to accessibility, visit the Oracle Accessibility Program website at
`http://www.oracle.com/pls/topic/lookup?ctx=acc&id=docacc`.

Access to Oracle Support

Oracle customers have access to electronic support through My Oracle Support. For information, visit http://www.oracle.com/pls/topic/lookup?ctx=acc&id=info or visit http://www.oracle.com/pls/topic/lookup?ctx=acc&id=trs if you are hearing impaired.

Related Documents

For more information, see these Oracle resources:

- *Oracle Database New Features Guide* for information about the differences between Oracle Database 12*c* and Oracle Database 12*c* Enterprise Edition with respect to available features and options. This book also describes features new to Oracle Database 12*c* Release 1 (12.1).
- *Oracle Database XML Java API Reference*
- *Oracle XML Developer's Kit Programmer's Guide*
- *Oracle Database Error Messages*. Oracle Database error message documentation is available only as HTML. If you have access to only printed or PDF Oracle Database documentation, you can browse the error messages by range. Once you find the specific range, use the search (find) function of your Web browser to locate the specific message. When connected to the Internet, you can search for a specific error message using the error message search feature of the Oracle Database online documentation.
- *Oracle Text Application Developer's Guide*
- *Oracle Text Reference*
- *Oracle Database Concepts*
- *Oracle Database Java Developer's Guide*
- *Oracle Database Development Guide*
- *Oracle Database Advanced Queuing User's Guide*
- *Oracle Database PL/SQL Packages and Types Reference*

Many of the examples in this book use the sample schemas, which are installed by default when you select the Basic Installation option with an Oracle Database installation. Refer to *Oracle Database Sample Schemas* for information about how these schemas were created and how you can use them yourself.

To download free release notes, installation documentation, white papers, or other collateral, please visit the Oracle Technology Network (OTN). You must register online before using OTN; registration is free and can be done at

http://www.oracle.com/technetwork/community/join/overview/index.html

If you already have a user name and password for OTN, then you can go directly to the documentation section of the OTN Web site at

http://www.oracle.com/technetwork/indexes/documentation/

For additional information, see:

- http://www.w3.org/TR/xml/ – XML (language)
- http://www.xml.com/pub/a/98/10/guide0.html – XML introduction
- http://www.w3.org/XML/Schema – XML Schema

- http://www.w3.org/2001/XMLSchema – XML Schema
- http://www.w3.org/TR/xmlschema-0/ – XML Schema: primer
- http://www.w3.org/TR/xmlschema-1/ – XML Schema: structures
- http://www.w3.org/TR/xmlschema-2/ – XML Schema: data types
- http://www.oasis-open.org/cover/schemas.html – XML Schema
- http://www.xml.com/pub/a/2000/11/29/schemas/part1.html – XML Schema
- http://xml.coverpages.org/xmlMediaMIME.html – media/MIME types
- http://www.w3.org/TR/xptr/ – XPointer
- http://www.w3.org/TR/xpath – XPath 1.0
- http://www.w3.org/TR/xpath20/ – XPath 2.0
- http://www.zvon.org/xxl/XPathTutorial/General/examples.html – XPath
- *XML In a Nutshell*, by Elliotte Rusty Harold and W. Scott Means, O'Reilly, January 2001, http://www.oreilly.com/catalog/xmlnut/chapter/ch09.html
- http://www.w3.org/TR/2002/NOTE-unicode-xml-20020218/ – Unicode in XML
- http://www.w3.org/TR/xml-names/ – XML namespaces
- http://www.w3.org/TR/xml-infoset/ – information sets
- http://www.w3.org/DOM/ – Document Object Model (DOM)
- http://www.w3.org/TR/xslt – XSLT
- http://www.w3.org/TR/xsl – XSL
- http://www.oasis-open.org/cover/xsl.html – XSL
- http://www.zvon.org/xxl/XSLTutorial/Output/index.html – XSL
- http://www.w3.org/2002/ws/Activity.html – Web services
- http://www.ietf.org/rfc/rfc959.txt – RFC 959: FTP Protocol Specification
- ISO/IEC 13249-2:2000, Information technology - Database languages - SQL Multimedia and Application Packages - Part 2: Full-Text, International Organization For Standardization, 2000
- http://download.oracle.com/javaee/1.2.1/api/index.html – XML and Java

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Note: Throughout this manual, "**XML Schema**" refers to the XML Schema 1.0 recommendation, http://www.w3.org/XML/Schema.

Conventions

The following text conventions are used in this document:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
italic	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.

Convention	Meaning
`monospace`	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

Code Examples

The code examples in this book are for illustration only. In many cases, however, you can copy and paste parts of examples and run them in your environment.

Standard Database Schemas

Many of the examples in this book use the standard database schemas that are included in your database. In particular, database schema `OE` contains XML purchase-order documents in `XMLType` table `purchaseorder`, and XML documents with warehouse information in `XMLType` column `warehouse_spec` of table `warehouses`.

The purchase-order documents are also contained in Oracle XML DB Repository, under the repository path `/home/OE/PurchaseOrders/2002/`. The XML schema that governs these documents is file `purchaseorder.xsd`, at repository location `/home/OE/purchaseorder.xsd`. An XSLT stylesheet that is used in some examples to transform purchase-order documents is file `purchaseorder.xsl`, at repository location `/home/OE/purchaseorder.xsl`. This XML schema and stylesheetstylesheet can also be found in Appendix A, "Oracle-Supplied XML Schemas and Examples".

See Also:

- *Oracle Database Sample Schemas* for information about database schema `HR`
- *Oracle Database Sample Schemas* for information about database schema `OE`

Pretty Printing of XML Data

To promote readability, especially of lengthy or complex XML data, output is sometimes shown pretty-printed (formatted) in code examples.

Execution Plans

Some of the code examples in this book present execution plans. These are for illustration only. Running examples that are presented here in your environment is likely to result in different execution plans from those presented here.

Reminder About Case Sensitivity

When examining the examples in this book, keep in mind the following:

- SQL is case-insensitive, but names in SQL code are implicitly uppercase, unless you enclose them in double quotation marks (`"`).
- XML is case-sensitive. You must refer to SQL names in XML code using the correct case: uppercase SQL names must be written as uppercase.

For example, if you create a table named `my_table` in SQL without using double quotation marks, then you must refer to it in XML code as "`MY_TABLE`".

Syntax Descriptions

Syntax descriptions are provided in this book for various SQL, PL/SQL, or other command-line constructs in graphic form or Backus Naur Form (BNF). See *Oracle*

Database SQL Language Reference for information about how to interpret these descriptions.

Changes in This Release for Oracle XML DB Developer's Guide

This preface contains:

Changes in Oracle Database 12*c* Release 1 (12.1.0.2) for Oracle Database

The following are changes in *Oracle XML DB Developer's Guide* for Oracle Database 12*c* Release 1 (12.1.0.2).

New Features

The following features are new in this release.

JSON Support

Oracle Database now supports JavaScript Object Notation (JSON). See also Chapter 39, "JSON in Oracle Database" on page 39-1.

PL/SQL Subprograms For Realm Configuration

PL/SQL subprograms `getHTTPConfigRealm` and `setHTTPConfigRealm` have been added to package `DBMS_XDB_CONFIG`.

Changes in Oracle Database 12*c* Release 1 (12.1.0.1) for Oracle XML DB

The following are changes in *Oracle XML DB Developer's Guide* for Oracle Database 12*c* Release 1 (12.1.0.1).

New Features

The following features are new in this release.

Oracle XML DB is Mandatory – You Cannot Uninstall it

Oracle XML DB is now a mandatory component of Oracle Database. You cannot uninstall it, and there is no option not to include it when you create Oracle Database. It is automatically installed when you create a new database or (if not existing already) when you upgrade an existing database to Oracle Database 12*c*. See also "Automatic Installation of Oracle XML DB" on page 35-3.

XQuery Update Support

Oracle XML DB now supports XQuery Update. The Oracle-specific SQL functions for updating XML data are deprecated.

See Also:

- Chapter 4, "XQuery and Oracle XML DB"
- "Updating XML Data" on page 5-26
- "Deprecated Features" on page lvi regarding deprecated Oracle SQL functions for updating XML data

XQuery Full Text Support

Oracle XML DB now supports XQuery Full Text.

See Also:

- Chapter 4, "XQuery and Oracle XML DB"
- "Indexing XML Data for Full-Text Queries" on page 6-48

New XQuery Extension-Expression Pragmas

The following XQuery extension-expression pragmas are new:

- `(#ora:child-element-name` *name* `#)` – Specify the name to use for a child element that is inserted.
- `(#ora:no_schema #)` – Do not raise an error if an XQuery Full Text expression is used with XML Schema-based `XMLType` data.
- `(#ora:use_xmltext_idx #)` – Use an XML search index, if available, to evaluate the query. Do not use an `XMLIndex` index or streaming evaluation.

See Also: "Oracle XQuery Extension-Expression Pragmas" on page 4-21

Replication and Rolling Upgrade Support

The following new features provide better support for replication and rolling upgrade.

Oracle GoldenGate and Oracle Data Guard SQL Apply Support for XMLType Oracle GoldenGate replication and Oracle Data Guard SQL Apply (logical standby) are now supported for all `XMLType` storage models.

See Also:

- *Oracle GoldenGate Oracle Installation and Setup* for information about replication of `XMLType` data using Oracle GoldenGate
- *Oracle GoldenGate* for information about Oracle GoldenGate
- *Oracle Data Guard Concepts and Administration* for information about data types supported by SQL Apply

Rolling Upgrade Supports Oracle XML DB Repository When you perform a rolling upgrade, Oracle XML DB Repository operations are applied on the standby database as part of the SQL apply step. See "Upgrade or Downgrade of an Existing Oracle XML DB Installation" on page 35-1 for applicable restrictions.

Parallel DML Support for XMLType

Support for parallel DML has been improved for `XMLType` storage model binary XML using SecureFiles LOBs. The performance and scalability have been improved for both `CREATE TABLE AS SELECT` and `INSERT AS SELECT`.

> **See Also:** *Oracle Database SecureFiles and Large Objects Developer's Guide*

XMLIndex Improvements

Indexing XML data using `XMLIndex` has been improved in the following ways.

XMLIndex Index Synchronization Improvements Index synchronization has been improved in these ways:

- Less undo space is used.
- If an error is raised during indexing then most of the index synchronization work is saved.

XMLIndex Support for Hash Partitioning You can create a locally partitioned `XMLindex` index on `XMLType` tables and columns that you have partitioned using hash partitioning (in addition to range and list partitioning).

> **See Also:** "XMLIndex Partitioning and Parallelism" on page 6-36

PL/SQL Package DBMS_XDB Is Split

The subprograms and constants of PL/SQL package `DBMS_XDB` have been divided among the following packages:

- `DBMS_XDB_ADMIN`
- `DBMS_XDB_CONFIG`
- `DBMS_XDB_REPOS`

Packages `DBMS_XDB_CONFIG` and `DBMS_XDB_REPOS` are new in Oracle Database 12*c* Release 1 (12.1.0.1). Package `DBMS_XDB` continues to exist for backward compatibility.

> **See Also:**
>
> - *Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDB_CONFIG"
> - "Deprecated Features" on page lvi regarding deprecated PL/SQL subprograms and constants moved from DBMS_XDB to DBMS_XDB_CONFIG
> - *Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDB_REPOS"

Digest Access Authentication Access to the Repository

Users can now access Oracle XML DB Repository using digest access authentication (also known as digest authentication), in addition to basic authentication. This

provides encryption of user credentials (name, password, etc.) without the overhead of complete data encryption.

Note that user credentials are case-sensitive. In particular, a user name to be authenticated must exactly match the name as it was created (which by default is all uppercase).

See Also:

- "Configuration and Management of Authentication Mechanisms for HTTP" on page 28-9 for how to configure digest authentication
- "Upgrade or Downgrade of an Existing Oracle XML DB Installation" on page 35-1 for installation, upgrade, and downgrade considerations

DBFS Support

You can now access Oracle Database File System (DBFS) files and folders from Oracle XML DB Repository, under the repository path `/dbfs`. This new feature provides you with FTP and HTTP(S)/WebDAV access to DBFS files and folders.

See Also:

- *Oracle Database SecureFiles and Large Objects Developer's Guide*
- *Oracle Database Upgrade Guide*

XQuery API for Java (XQJ) Support

You can now use Oracle XML Developer's Kit and XQuery API for Java (XQJ) to access XML data in the database using XQuery expressions from Java programs. In particular, you can access XML data stored in remote databases from a local Java program.

See Also:

- "Using XQuery with XQJ to Access Database Data" on page 5-22
- *Oracle XML Developer's Kit Programmer's Guide* for complete information about using XQJ

Deprecated Features

The following features are deprecated in this release, and may be desupported in a future release.

- `CLOB` storage of `XMLType`, also known as unstructured storage, is deprecated. Use binary XML storage of `XMLType` instead.

  If you need to preserve insignificant whitespace then store two copies of your original XML document: one as an `XMLType` instance for database use and XML processing, the other as a `CLOB` instance to provide document fidelity.
- Creation of an `XMLIndex` index over an XML fragment stored as a `CLOB` instance embedded in object-relational `XMLType` data is deprecated. If you need to index the data in such a fragment then store the document using binary XML storage, not object-relational storage.
- The following PL/SQL subprograms in package `DBMS_XMLSCHEMA` are deprecated:
  - `generateSchema`
  - `generateSchemas`

There are no replacements for these constructs and there is no workaround for this change.

- PL/SQL package `DBMS_XDB_CONFIG` is new. All Oracle XML DB configuration functions, procedures, and constants have been moved from package `DBMS_XDB` to `DBMS_XDB_CONFIG`. They are *deprecated* for package `DBMS_XDB`. Oracle recommends that you use them in package `DBMS_XDB_CONFIG` instead.

  These are the subprograms that are deprecated in package `DBMS_XDB`:

  - `ADDHTTPEXPIREMAPPING`
  - `ADDMIMEMAPPING`
  - `ADDSCHEMALOCMAPPING`
  - `ADDSERVLET`
  - `ADDSERVLETMAPPING`
  - `ADDSERVLETSECROLE`
  - `ADDXMLEXTENSION`
  - `CFG_GET`
  - `CFG_REFRESH`
  - `CFG_UPDATE`
  - `DELETEHTTPEXPIREMAPPING`
  - `DELETEMIMEMAPPING`
  - `DELETESCHEMALOCMAPPING`
  - `DELETESERVLET`
  - `DELETESERVLETMAPPING`
  - `DELETESERVLETSECROLE`
  - `DELETEXMLEXTENSION`
  - `GETFTPPORT`
  - `GETHTTPPORT`
  - `GETLISTENERENDPOINT`
  - `SETFTPPORT`
  - `SETHTTPPORT`
  - `SETLISTENERENDPOINT`
  - `SETLISTENERLOCALACCESS`

  These are the constants that are deprecated in package `DBMS_XDB`:

  - `XDB_ENDPOINT_HTTP`
  - `XDB_ENDPOINT_HTTP2`
  - `XDB_PROTOCOL_TCP`
  - `XDB_PROTOCOL_TCPS`

  See Also: *Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDB_CONFIG"

- All Oracle SQL functions for updating XML data are deprecated. Oracle recommends that you use XQuery Update instead. These are the deprecated XML updating functions:
  - `updateXML`
  - `insertChildXML`
  - `insertChildXMLbefore`
  - `insertChildXMLafter`
  - `insertXMLbefore`
  - `insertXMLafter`
  - `appendChildXML`
  - `deleteXML`

  See Also: Appendix C, "Deprecated Functions for Updating XML Data"

- Oracle SQL function `sys_xmlgen` is deprecated. Oracle recommends that you use the SQL/XML generation functions instead.

  See Also: "Generation of XML Data Using SQL Functions" on page 8-2

- The following Oracle XQuery functions are deprecated. Use the corresponding standard XQuery functions instead, that is, the functions with the same names but with namespace prefix `fn`.
  - `ora:matches` – use `fn:matches` instead
  - `ora:replace` – use `fn:replace` instead
- The following Oracle constructs that provide support for XML translations are deprecated.
  - PL/SQL package `DBMS_XMLTRANSLATIONS`
  - Oracle XPath function `ora:translate`
  - XML Schema annotations `xdb:maxOccurs`, `xdb:srclang`, and `xdb:translate`

  There are no replacements for these constructs and there is no workaround for this change.

  See Also: Appendix D, "Deprecated Constructs for XML Translation"

- The following XML Schema annotations are deprecated:
  - `xdb:defaultTableSchema`
  - `xdb:maintainOrder`
  - `xdb:mapUnboundedStringToLob`
  - `xdb:maxOccurs`[1]

[1] See also "Deprecated Features" on page lvi regarding deprecated support for XML translations.

- `xdb:SQLCollSchema`
- `xdb:SQLSchema`
- `xdb:srclang`[1]
- `xdb:storeVarrayAsTable`
- `xdb:translate`[1]

There are no replacements for these constructs, and there is no workaround for this change.

- The value `xml_clobs` for export parameter `data_options` is *deprecated* starting with Oracle Database 12*c* Release 1 (12.1).

See Also: "Overview of Exporting and Importing XMLType Tables" on page 37-1

Desupported Features

The following features are no longer supported by Oracle. See *Oracle Database Upgrade Guide* for a complete list of desupported features in this release.

- `CTXSYS.CTXXPATH` index is desupported. Use `XMLIndex` indexes instead

Changes in Oracle Database 11*g* Release 2 (11.2.0.3) for Oracle XML DB

The following are changes in *Oracle XML DB Developer's Guide* for Oracle Database 11g Release 2 (11.2.0.3).

Deprecated Features

The following features are deprecated in this release, and may be desupported in a future release.

- PL/SQL procedure `DBMS_XDB_ADMIN.createRepositoryXMLIndex`
- PL/SQL procedure `DBMS_XDB_ADMIN.XMLIndexAddPath`
- PL/SQL procedure `DBMS_XDB_ADMIN.XMLIndexRemovePath`
- PL/SQL procedure `DBMS_XDB_ADMIN.dropRepositoryXMLIndex`
- XML schema annotation (attribute) `csx:encodingType`
- `XMLIndex` index on `CLOB XMLType` data that is embedded within object-relational `XMLType` data

Other Changes

The following PL/SQL procedures have been moved from package `DBMS_XDB` to package `DBMS_XDB_ADMIN` in Oracle Database 11*g* Release 2 (11.2.0.3):

- `moveXDB_tablespace`
- `rebuildHierarchicalIndex`

Changes in Oracle Database 11*g* Release 2 (11.2.0.2) for Oracle XML DB

The following are changes in *Oracle XML DB Developer's Guide* for Oracle Database 11g Release 2 (11.2.0.2).

New Features

The following Oracle XML DB features are new in Oracle Database 11*g* Release 2 (11.2.0.2).

Default Storage Model for XMLType

The default `XMLType` storage model is used if you do not specify a storage model when you create an `XMLType` table or column. Prior to Oracle Database 11*g* Release 2 (11.2.0.2), `CLOB` storage was used by default. The default storage model is now binary XML storage.

Note: You can create a new table that uses binary XML storage and populate it with existing `XMLType` data that is stored using `CLOB` storage. Use `CREATE TABLE AS SELECT`..., selecting from the existing data.

This functionality is available starting with Oracle Database 11g Release 2 (11.2.0.2).

Default LOB Storage for Binary XML

`XMLType` data that uses the binary XML storage model is stored internally using large objects (LOBs). Prior to Oracle Database 11*g* Release 2 (11.2.0.2), binary XML data was stored by default using the BasicFiles LOB storage option. By default, LOB storage for binary XML data now uses the SecureFiles LOB storage option whenever possible.

If SecureFiles LOB storage is not possible then the default behavior uses BasicFiles LOB storage. This can occur if either of the following is true:

- The tablespace for the `XMLType` table does not use automatic segment space management.
- A setting in file `init.ora` prevents SecureFiles LOB storage. For example, see parameter `DB_SECUREFILE`.

See Also:

- *Oracle Database Administrator's Guide* for information about automatic segment space management
- *Oracle Database Reference* for information about parameter `DB_SECUREFILE`
- "Deprecated Features" on page 3-lxi

This functionality is available starting with Oracle Database 11g Release 2 (11.2.0.2).

XQuery Pragma ora:defaultTable for Repository Query Performance

Previously, to obtain optimal performance for XQuery expressions that use `fn:doc` and `fn:collection` over Oracle XML DB Repository resources, you needed to carry out explicit joins with `RESOURCE_VIEW`. The new XQuery extension-expression pragma `ora:defaultTable` now performs the necessary joins automatically.

This functionality is available starting with Oracle Database 11g Release 2 (11.2.0.2).

XML Diagnosability Mode: SQL*Plus System Variable XMLOptimizationCheck

You can use the SQL*Plus `SET` command with the new system variable `XMLOptimizationCheck` to turn on an XML diagnosability mode for SQL. When this mode is on, execution plans are automatically checked for XPath rewrite, and if a plan

is suboptimal then an error is raised and diagnostic information is written to the trace file indicating which operators are not rewritten.

This functionality is available starting with Oracle Database 11g Release 2 (11.2.0.2).

> **See Also:** "Diagnosing XQuery Optimization: XMLOptimizationCheck" on page 5-45

Deprecated Features

The following features are deprecated in this release, and may be desupported in a future release.

- `XMLType` data stored as binary XML using BasicFiles LOB storage. See also the new feature "Default LOB Storage for Binary XML" on page lx.
- Oracle XQuery function `ora:view` – Use XQuery functions `fn:doc` and `fn:collection` instead. See Chapter 4, "XQuery and Oracle XML DB".

Changes in Oracle Database 11*g* Release 2 (11.2.0.1) for Oracle XML DB

The following are changes in *Oracle XML DB Developer's Guide* for Oracle Database 11g Release 2 (11.2.0.1).

New Features

The following Oracle XML DB features are new in Oracle Database 11*g* Release 2 (11.2.0.1).

Partitioning XMLType Tables and Columns

For `XMLType` data stored object-relationally, when you partition a base `XMLType` table or a base table with an `XMLType` column, any collection tables that use heap-based table storage are now, by default, automatically equipartitioned also. Equipartitioning means that there is a corresponding collection-table partition for each partition of the base table. A child element is stored in the collection-table partition that corresponds to the base-table partition of its parent element.

> **See Also:** "Partitioning of XMLType Tables and Columns Stored Object-Relationally" on page 18-30

Access Control Enhancements

Access control lists (ACLs) have been enhanced in various ways, to provide fine-grained access control that you can customize. You can define your own privileges and associate them with users and roles in flexible ways. Access control entries (ACEs) can stipulate start and end dates. You can control access for application users and roles that are not necessarily the same as database users and roles.

> **See Also:** Chapter 27, "Repository Access Control"

Repository Read and Write Performance Enhancements

Performance has been improved for Oracle XML DB Repository read and write operations.

Binary XML Performance Enhancements and Partitioning

The performance of queries and DML operations on binary XML tables has been improved, and you can now partition binary XML tables, using a virtual column as the partitioning key.

XMLIndex Enhancements

You can use `XMLIndex` to index islands of structured XML content embedded in content that is generally unstructured. An `XMLIndex` index can thus index both structured and unstructured XML content.

You can create a local `XMLIndex` index on data in partitioned `XMLType` tables.

> **See Also:** "XMLIndex" on page 6-6

Cost-Based XPath Rewrite

You can use a new optimizer hint to request cost-based optimization of XQuery expressions.

> **See Also:** "Rule-Based and Cost-Based XQuery Optimization" on page 5-41

New Default Type Mappings for Object-Relational Storage

For `XMLType` data that is stored object-relationally, XML Schema data types are mapped to SQL data types. Oracle defines a set of *default* mappings, but you can override these by specifying particular mappings to be used for specific parts of a given XML schema.

Oracle now offers a *new set of default mappings*. The following lists the differences from the default mappings available prior to Oracle Database 11*g* Release 2 (11.2.0.1). In the *new* set of default mappings:

- `xs:float` is mapped to `BINARY FLOAT`, instead of `NUMBER`.
- `xs:dateTime` is mapped to `TIMESTAMP WITH TIMEZONE`, instead of `TIMESTAMP`.
- An instance of `xs:string` that is longer than 4000 bytes is of type `CLOB` by default, instead of type `VARCHAR2(4000)`.

By default, the *old* set of default mappings is used, for reasons of backward compatibility. To use the new default mappings instead, you must do *both* of the following:

- Set database parameter `compatible` in file `init.ora` to 11.2 or higher.
- Set element `default-type-mappings` in the Oracle XML DB configuration file, `xdbconfig.xml`, to `post-11.2`.

> **See Also:** "How to Map XML Schema Data Types to SQL Data Types" on page 18-17

Deprecated Features

The following Oracle XML DB constructs are *deprecated* in Oracle Database 11*g* Release 2 (11.2.0.1). They are still supported in 11.2.0.1 for backward compatibility, but Oracle recommends that you do not use them in new applications.

- Oracle SQL function `extract` – Use SQL/XML function `XMLQuery` instead. See "XMLQUERY SQL/XML Function in Oracle XML DB" on page 4-9.
- Oracle SQL function `extractValue` – Use SQL/XML function `XMLTable` or SQL/XML functions `XMLCast` and `XMLQuery` instead.
  - See "SQL/XML Functions XMLQUERY, XMLTABLE, XMLExists, and XMLCast" on page 4-9 for information about using function `XMLTable`

  - See "XMLCAST SQL/XML Function in Oracle XML DB" on page 4-16 for information about using functions `XMLCast` and `XMLQuery`
- Oracle SQL function `existsNode` – Use SQL/XML function `XMLExists` instead. See "XMLEXISTS SQL/XML Function in Oracle XML DB" on page 4-14.
- Oracle SQL function `XMLSequence` – Use SQL/XML function `XMLTable` instead. See "XMLTABLE SQL/XML Function in Oracle XML DB" on page 4-11.
- Oracle XPath function `ora:instanceof` – Use XQuery operator `instance of` instead.
- Oracle XPath function `ora:instanceof-only` – Use XML Schema attribute `xsi:type` instead.
- PL/SQL `XMLType` methods `getStringVal()`, `getCLOBVal()`, and `getBLOBVal()`, – Use SQL/XML function `XMLSerialize` instead. See "XMLSERIALIZE SQL/XML Function" on page 8-16.
- PL/SQL `XMLType` method `getNamespace()` – Use XQuery function `fn:namespace-uri` instead.
- PL/SQL `XMLType` method `getRootElement()` – Use XQuery function `fn:local-name` instead.
- Function-based indexes on `XMLType` – Use `XMLIndex` with a structured component instead. See "Function-Based Indexes Are Deprecated for XMLType" on page 6-5.

Changes in Oracle Database 11*g* Release 1 (11.1) for Oracle XML DB

The following are changes in *Oracle XML DB Developer's Guide* for Oracle Database 11g Release 1 (11.1).

New Features

The following Oracle XML DB features are new in Oracle Database 11*g* Release 1 (11.1).

Binary XML

Binary XML is a new storage model for abstract data type `XMLType`, joining the existing storage models of object-relational and `CLOB` storage. Binary XML is XML-Schema aware, but it can also be used with XML data that is not based on an XML schema. See "XMLType Storage Models" on page 1-11.

See Also:

- *Oracle Database Development Guide* for an overview of `XMLType` data stored as binary XML
- *Oracle Database SQL Language Reference* for information about creating `XMLType` tables and columns stored as binary XML
- *Oracle Database XML Java API Reference* for information about manipulating binary XML data using Java
- *Oracle Database XML C API Reference* for information about manipulating binary XML data using C

XMLIndex

A new index type is provided for `XMLType`: `XMLIndex`. This can greatly improve the performance of XPath-based predicates and fragment extraction for `XMLType` data,

whether based on an XML schema or not. The new index type is a (logical) domain index that consists of underlying physical tables and secondary indexes. See Chapter 6, "Indexes for XMLType Data".

Note: The `CTXSYS.CTXXPath` index is *deprecated* in Oracle Database 11g Release 1 (11.1). The functionality that was provided by `CTXXPath` is now provided by `XMLIndex`.

Oracle recommends that you replace `CTXXPath` indexes with `XMLIndex` indexes. The intention is that `CTXXPath` will no longer be supported in a future release of the database.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_XMLINDEX`

XMLType OCTs Now Use Heap Storage Instead of IOTs

You can store collections of XML elements as ordered collection tables (OCTs). OCTs now use heap storage, by default. In prior releases, OCTs were index-organized tables (IOTs), by default. A new XML schema registration option, `REGISTER_NT_AS_IOT`, forces the use of IOTs.

Default Value of XML Schema Annotation xdb:storeVarrayAsTable Is Now true

In prior releases, the default value of XML schema annotation `xdb:storeVarrayAsTable` was `false`; the default value is now `true`. This means that by default an XML collection is stored as a set of rows in an ordered collection table (OCT). Each row corresponds to an element in the collection. With annotation `xdb:storeVarrayAsTable = "false"`, the entire collection is instead serialized as a varray and stored in a LOB column.

Using `xdb:storeVarrayAsTable = "true"` facilitates the efficient use of collections: queries, updates, and creation of B-tree indexes.

Repository Events

Applications can now register listeners with handlers for events associated with Oracle XML DB Repository operations such as creating, deleting, and updating a resource. See Chapter 30, "Oracle XML DB Repository Events".

See Also:

- *Oracle Database XML Java API Reference* for new Java methods
- *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_XEVENT`
- *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_RESCONFIG`
- *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_XDBRESOURCE`

Support for Content Repository API for Java (JCR: JSR-170)

Oracle XML DB now supports Content Repository API for Java (JCR) and the JSR-170 standard. You can access Oracle XML DB Repository using the JCR APIs. See Chapter 31, "Oracle XML DB Content Connector".

See Also: *Oracle Database XML Java API Reference* for new Java methods

New Repository Resource Link Types

You can now create weak folder links to represent Oracle XML DB Repository folder-child relationships. Hard links are still available, as well. See "Link Types" on page 21-10.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for updates to PL/SQL package `DBMS_XDB`
- *Oracle Database SQL Language Reference* for updates to function `under_path`

Support for WebDAV Privileges and New Oracle XML DB Privileges

All WebDAV privileges are now supported by Oracle XML DB Repository. In addition, there are some new Oracle XML DB-specific atomic privileges. See Chapter 27, "Repository Access Control".

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_NETWORK_ACL_ADMIN`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_TCP`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_INADDR`

Web Services

You can now access Oracle Database through Web services. You can write and deploy Web services that can query the database using SQL or XQuery, or access stored PL/SQL functions and procedures. See Chapter 34, "Native Oracle XML DB Web Services"

In-Place XML Schema Evolution

In many cases, you can now evolve XML schemas without copying the corresponding XML instance documents. See Chapter 20, "XML Schema Evolution".

See Also: *Oracle Database PL/SQL Packages and Types Reference* for updates to PL/SQL package `DBMS_XMLSCHEMA`

Support for Recursive XML Schemas

Oracle XML DB now performs XPath rewrite on some queries that use '`//`' in XPath expressions to target nodes at multiple or arbitrary depths, even when the XML data conforms to a recursive XML schema. See "Support for Recursive Schemas" on page 18-47

See Also: *Oracle Database PL/SQL Packages and Types Reference* for updates to PL/SQL package `DBMS_XMLSCHEMA`

Support for XLink and XInclude

Oracle XML DB now supports the XLink and XInclude standards. See Chapter 23, "How To Use XLink and XInclude with Oracle XML DB".

Support for XML Translations

You can now associate natural-language translation information with XML schemas and corresponding instance documents. This includes support for standard attributes `xml:lang` and `xml:srclang`. See "XML Translations (Deprecated)" on page D-1.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_XMLTRANSLATIONS`

Support for Large XML Nodes

The previous 64K limit on text nodes and attribute values has been lifted. Text nodes and attribute values are no longer limited in size to 64K bytes each. New streaming push and pull APIs are available in PL/SQL, Java, and C to provide virtually unlimited node sizes. See "Large Node Handling Using DBMS_XMLDOM" on page 11-14 for information about handling large nodes in PL/SQL and "Large XML Node Handling with Java" on page 13-17.

> **See Also:**
>
> - *Oracle Database SQL Language Reference* for information about creating `XMLType` tables and columns stored as binary XML
> - *Oracle Database XML Java API Reference* for information about new Java methods
> - *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_SDA` and updates to PL/SQL package `DBMS_XMLDOM`

Unified Java API

The Java XML APIs in Oracle XML DB and Oracle XML Developer's Kit have been unified.

> **See Also:**
>
> - *Oracle XML Developer's Kit Programmer's Guide*
> - *Oracle Database XML Java API Reference*, package `oracle.xml.parser.v2`

Oracle Data Pump Support for XMLType

Oracle Data Pump is now the recommended way to import and export `XMLType` data. See Chapter 37, "Export and Import of Oracle XML DB Data".

Support for XMLType by Oracle Streams and Logical Standby

Oracle Streams and logical standby now support `XMLType` stored as `CLOB`. Both XML schema-based and non-schema-based XML data are supported.

See Also:

- *Oracle Streams Concepts and Administration*
- *Oracle Data Guard Concepts and Administration*
- *Oracle Database Utilities*
- *Oracle Database Reference* for information on views `DBA_STREAMS_UNSUPPORTED` and `DBA_STREAMS_COLUMNS`

Oracle XML Developer's Kit Pull-Parser API (XML Events, JSR-173)

You can use the new Oracle XML Developer Kit (XDK) pull-parser API with Oracle XML DB. See "Using the Oracle XML Developer's Kit Pull Parser with Oracle XML DB" on page 14-10.

See Also:

- *Oracle Database XML C API Reference* for information about new C methods and types
- *Oracle XML Developer's Kit Programmer's Guide*

XQuery Standard Compliance

Oracle XML DB support for the XQuery language has been updated to reflect the latest version of the XQuery standard, W3C XQuery 1.0 Recommendation.

See Also:

- *Oracle XML Developer's Kit Programmer's Guide*
- `http://www.w3.org` for information about the XQuery language

Fine-Grained Access to Network Services Using PL/SQL

New atomic privileges are provided for access control entries (ACEs). These privileges are used for fine-grained PL/SQL access to network services.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for information on package `DBMS_NETWORK_ACL_ADMIN`

SQL/XML Standard Compliance and Performance Enhancements

Oracle XML DB support for the SQL/XML standard has been updated to reflect the latest version of the standard. This includes support for standard SQL functions `XMLExists` and `XMLCast`. See Chapter 4, "XQuery and Oracle XML DB" and "Generation of XML Data Using SQL Functions" on page 8-2.

See Also: *Oracle Database SQL Language Reference* for information about SQL/XML functions `XMLExists`, `XMLCast`, `XMLQuery`, `XMLTable`, and `XMLForest`.

XML-Update Performance Enhancements

The performance of SQL functions used to update XML data has been enhanced for XML schema-based data that is stored object-relationally. This includes XPath rewrite for SQL functions `updateXML`, `insertChildXML`, and `deleteXML`.

XQuery and SQL/XML Performance Enhancements

XQuery and SQL/XML performance enhancements include treatment of the following:

- User-defined XQuery functions
- XQuery prolog variables
- XQuery `count` function applied to the result of using a SQL/XML generation function
- Positional expressions in XPath predicates
- XQuery computed constructors
- SQL/XML function `XMLAgg`

XSLT Performance Enhancements

The performance of XSLT transformations using SQL function `XMLTransform` and `XMLType` method `transform()` has been enhanced.

Part I

Oracle XML DB Basics

Part I of this manual introduces Oracle XML DB. It contains the following chapters:

- Chapter 1, "Introduction to Oracle XML DB"
- Chapter 2, "Getting Started with Oracle XML DB"
- Chapter 3, "Overview of How To Use Oracle XML DB"

1

Introduction to Oracle XML DB

This chapter introduces the features and architecture of Oracle XML DB. It contains these topics:

Overview of Oracle XML DB

Oracle XML DB is a set of Oracle Database technologies related to high-performance handling of XML data: storing, generating, accessing, searching, validating, transforming, evolving, and indexing. It provides native XML support by encompassing both the SQL and XML data models in an interoperable way. Oracle XML DB is included as part of Oracle Database starting with Oracle9*i* Release 2 (9.2).

Oracle XML DB and the `XMLType` abstract data type make Oracle Database XML-aware. Storing XML data as an `XMLType` column or table lets the database perform XML-specific operations on the content. This includes XML validation and optimization. `XMLType` storage allows highly efficient processing of XML content in the database.

Oracle XML DB includes the following features:

- An abstract SQL data type, `XMLType`, for XML data.
- Enterprise-level Oracle Database features for XML content: reliability, availability, scalability, and security. XML-specific memory management and optimizations.
- Industry-standard ways to access and update XML data. You can use FTP, HTTP(S), and WebDAV to move XML content into and out of Oracle Database. Industry-standard APIs provide programmatic access and manipulation of XML content using Java, C, and PL/SQL.
- Ways to store, query, update, and transform XML data while accessing it using SQL and XQuery.
- Ways to perform XML operations on SQL data.

- Oracle XML DB Repository: a simple, lightweight repository where you can organize and manage database content, including XML content, using a file/folder/URL metaphor.
- Ways to access and combine data from disparate systems through gateways, using a single, common data model. This reduces the complexity of developing applications that must deal with data from different stores.
- Ways to use Oracle XML DB in conjunction with Oracle XML Developer's Kit (XDK) to build applications that run in the middle tier in either Oracle Fusion Middleware or Oracle Database.

Oracle XML DB functionality is partially based on the Oracle XML Developer's Kit C implementations of the relevant XML standards, such as XML Parser, XSLT Virtual Machine, XML DOM, and XML Schema Validator.

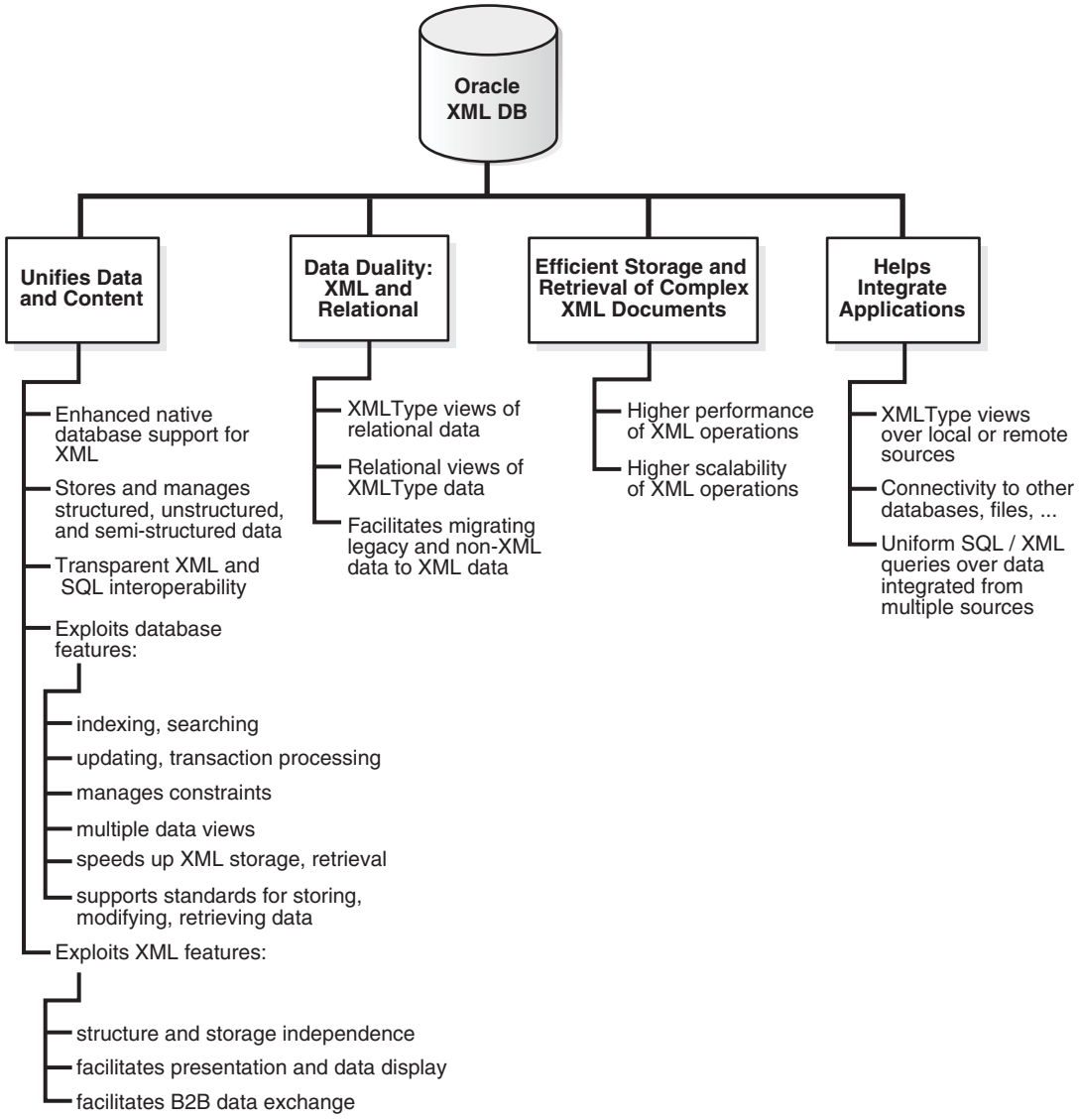
See Also:

- "XMLType Data Type" on page 1-10
- `http://www.oracle.com/technetwork/database-features/xmldb/overview/index.html` for the latest news and white papers about Oracle XML DB
- *Oracle XML Developer's Kit Programmer's Guide*

Oracle XML DB Benefits

This section describes several benefits of using Oracle XML DB. Figure 1–1 presents an overview.

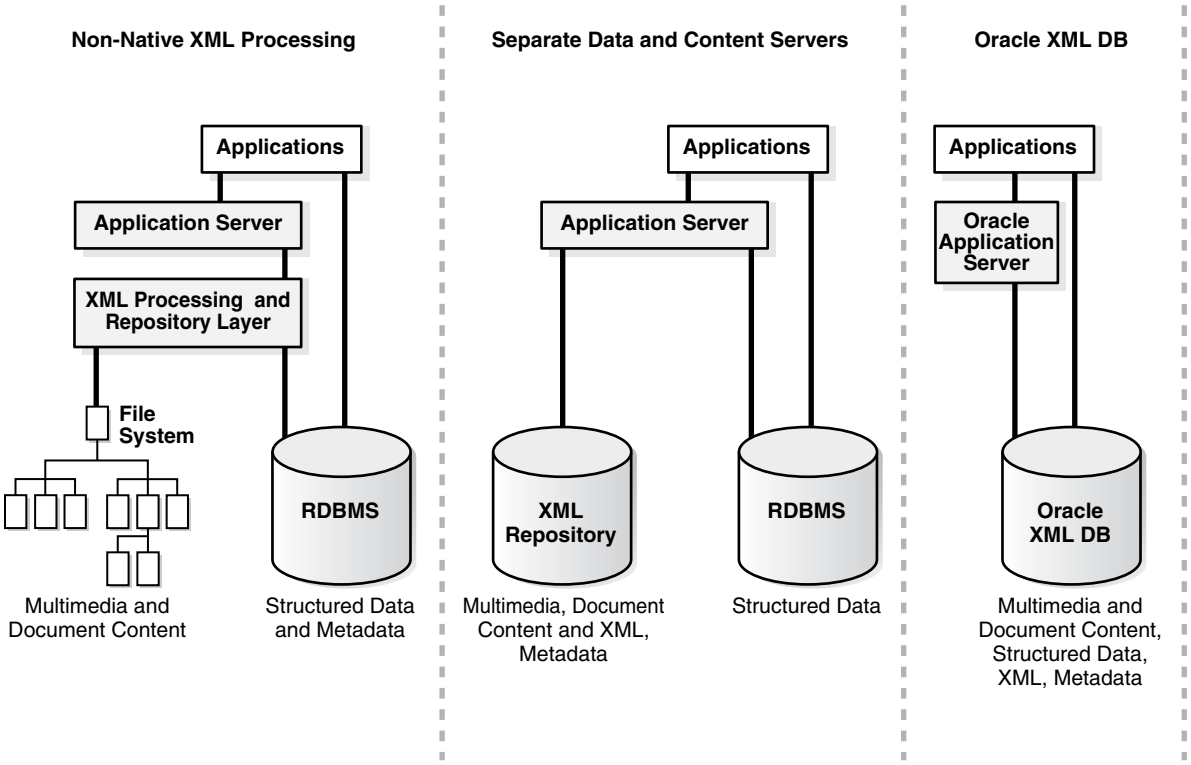
Figure 1–1 Oracle XML DB Benefits



Data and Content Unified

Most application data and Web content is stored in a relational database, a file system, or both. XML data is often used for data exchange, and it can be generated from a relational database or a file system. As the volume of XML data exchanged grows, the cost of regenerating this data grows, and these storage methods become less effective at accommodating XML content.

Figure 1–2 Unifying Data and Content: Some Common XML Architectures



Organizations often manage their structured data and unstructured data differently:

- Unstructured data, stored in tables, makes document access transparent and table access complex.
- Structured data, often stored in binary large objects (such as in `BLOB` instances), makes access more complex and table access transparent.

With Oracle XML DB, you can store and manage data that is structured, unstructured, and semi-structured using a standard data model and standard SQL and XML. You can perform SQL operations on XML documents and XML operations on object-relational (such as table) data.

Database Capabilities for Working with XML

Oracle Database has the following key database capabilities for working with XML:

- Indexing and search – Just as your database data can be more or less structured, so can your queries. One query can look for all product definitions created between March and April 2014. Another query can look for products whose descriptions contain the words "`wireless`" and "`router`" but not the term "`wireless router`".

  A query such as the former targets structured data, and it is typically supported by a B-tree index on a date column. A query such as the latter targets unstructured data, and for Oracle Database it is typically supported by an Oracle Text (full-text) index. Applications can of course combine structured and unstructured queries, and targeted data can be a mix of structured and unstructured data.

  For XML data the situation is similar. Oracle XML DB provides indexing features that let you target the gamut of XML possibilities, from data and queries that are highly structured to those that are highly unstructured.

See Also:

- Chapter 5, "Query and Update of XML Data"
- Chapter 8, "Generation of XML Data from Relational Data"
- "Indexing XML Data for Full-Text Queries" on page 6-48
- *Oracle Text Application Developer's Guide*
- *Oracle Text Reference*

- Updates and transaction processing – Commercial relational databases use fast updates of subparts of records, with minimal contention between users trying to update. As traditionally document-centric data participate in collaborative environments through XML, this requirement becomes more important. File or `CLOB` storage cannot provide the granular concurrency control that Oracle XML DB does.

  See Also: Chapter 5, "Query and Update of XML Data"

- Managing relationships – Data with any structure typically has foreign-key constraints. XML data stores generally lack this feature, so you must implement any constraints in application code. Oracle XML DB enables you to constrain XML data according to XML schema definitions, and hence achieve control over relationships that structured data has always enjoyed.

  See Also:

  - Chapter 17, "XML Schema Storage and Query: Basic"
  - The purchase-order examples in Chapter 5, "Query and Update of XML Data"

- Multiple views of data – Most enterprise applications need to group data together in different ways for different modules. This is why relational views are necessary—to allow for these multiple ways to combine data. By allowing views on XML, Oracle XML DB creates different logical abstractions on XML for, say, consumption by different types of applications.

  See Also: Chapter 10, "XMLType Views"

- Performance and scalability – Users expect data storage, retrieval, and query to be fast. Loading a file or `CLOB` value, and parsing, are typically slower than relational data access. Oracle XML DB dramatically speeds up XML storage and retrieval.

  See Also:

  - Chapter 2, "Getting Started with Oracle XML DB"
  - Chapter 3, "Overview of How To Use Oracle XML DB"

- Ease of development – Databases are foremost an application platform that provides standard, easy ways to manipulate, transform, and modify individual data elements. While typical XML parsers give standard read access to XML data they do not provide an easy way to modify and store individual XML elements. Oracle XML DB supports several standard ways to store, modify, and retrieve data. These include XML Schema, XQuery, XPath, DOM, and Java.

See Also:

- Chapter 4, "XQuery and Oracle XML DB"
- Chapter 13, "Java DOM API for XMLType"
- Chapter 24, "Repository Access Using RESOURCE_VIEW and PATH_VIEW"
- Chapter 26, "PL/SQL Access to Oracle XML DB Repository"

Advantages of Storing Data as XML in the Database

Storing data as XML in the database provides the following advantages.

- Storage independence: When you use relational design, your client programs must know where your data is stored, in what format, what table, and what the relationships are among those tables. `XMLType` enables you to write applications without that knowledge and lets database administrators map structured data to physical table and column storage.

  See Also: Chapter 21, "Accessing Oracle XML DB Repository Data"

- Ease of presentation: XML is understood natively by Web browsers, many popular desktop applications, and most Internet applications. Relational data is generally not accessible directly from applications. Additional programming is required to make relational data accessible to standard clients. Oracle XML DB stores data as XML and makes it available as XML outside the database. No extra programming is required to display database content.

  See Also:

  - Chapter 7, "Transformation and Validation of XMLType Data".
  - Chapter 8, "Generation of XML Data from Relational Data".
  - Chapter 10, "XMLType Views".

- Ease of interchange – XML is the language of choice in business-to-business (B2B) data exchange. If you are forced to store XML in an arbitrary table structure, you are using some kind of proprietary translation. Whenever you translate a language, information is lost and interchange suffers. By natively understanding XML and providing DOM fidelity in the storage/retrieval process, Oracle XML DB enables a clean interchange.

  See Also:

  - Chapter 7, "Transformation and Validation of XMLType Data"
  - Chapter 10, "XMLType Views"

Data Duality: XML and Relational

A key feature of Oracle XML DB is to let you work with XML data as if it were relational data and relational data as if it were XML data. You can leverage the power of the relational model when working with XML content, and you can leverage the flexibility of XML when working with relational content. You can use the most appropriate tools for different aspects of a particular business problem.

This duality means that the same data can be exposed as rows in a table and manipulated using SQL or exposed as nodes in an XML document and manipulated

using XQuery, the DOM, or XSL transformation. Access and processing techniques are independent of the underlying storage method.

These features can provide simple solutions to common business problems:

- You can generate XML data directly from a SQL query. You can transform the XML data into other formats, such as HTML, using the database-resident XSLT processor.
- You can access XML content without converting between different data formats, using SQL queries, on-line analytical processing (OLAP), and business-intelligence/data warehousing operations.
- You can perform text, spatial data, and multimedia operations on XML content.

Use XMLType Views If Your Data Is Not XML

`XMLType` views provide a way for you to wrap existing relational and object-relational data in XML format. This can be especially useful if your legacy data is not in XML format but you must migrate it to XML format. Using `XMLType` views, you need not alter your application code or the stored data.

To use `XMLType` views, you must first register an XML schema with annotations that represent a bidirectional mapping between XML Schema data types and either SQL data types or binary XML encoding types. You can then create an `XMLType` view conforming to this mapping, by providing an underlying query that constructs instances of the appropriate types.

See Also: Chapter 10, "XMLType Views"

Efficient Storage and Retrieval of Complex XML Documents

Users today face a performance barrier when storing and retrieving complex, large, or many XML documents. Oracle XML DB provides high performance and scalability for XML operations. The major performance features are:

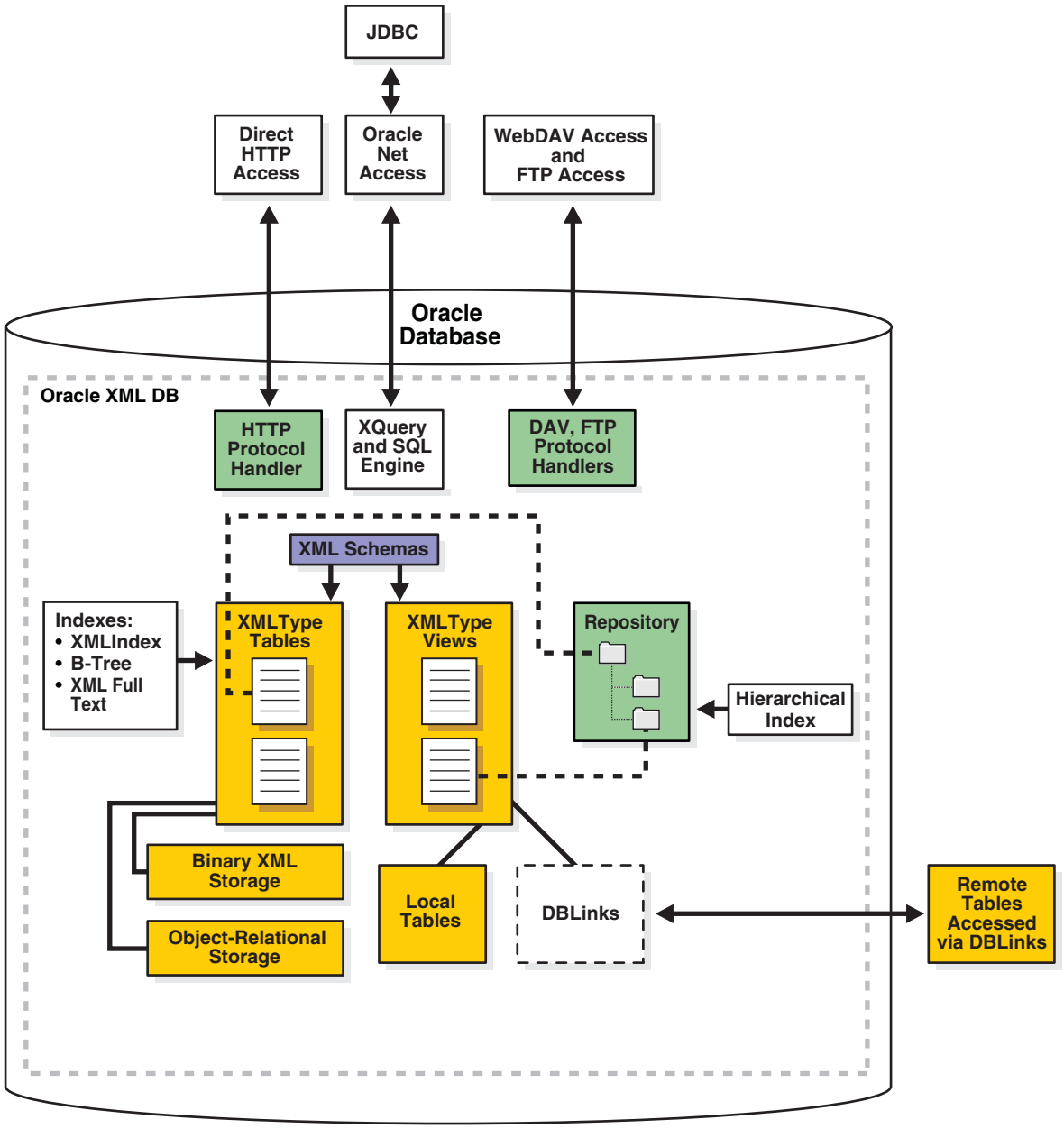
- Native `XMLType`. Abstract data type `XMLType` has two storage models, each optimized to work efficiently for a particular set of use cases. See Chapter 5, "Query and Update of XML Data" and Chapter 16, "Choice of XMLType Storage and Indexing"
- Optimized processing of XQuery, XPath, and XSLT. See "Performance Tuning for XQuery" on page 5-39 and Chapter 7, "Transformation and Validation of XMLType Data".
- Indexing XML data for structured or full-text search. See Chapter 6, "Indexes for XMLType Data" and Appendix E, "Full-Text Search over XML Data Without XQuery".
- A lazily evaluated virtual DOM. See "PL/SQL DOM API for XMLType (DBMS_XMLDOM)" on page 11-4.
- A hierarchical index over Oracle XML DB Repository. See "Performance Tuning of Oracle XML DB Repository Operations" on page 24-19.
- Parallelism and Oracle Exadata Smart Scan. Query and update of XML data can be carried out in parallel. Oracle Exadata Smart Scan is enabled automatically for XML data.

Oracle XML DB Architecture

Figure 1–3 shows the software architecture of Oracle XML DB. The main features are:

- Storage of `XMLType` tables and views.
  - You can index `XMLType` tables and views using `XMLIndex`, B-tree, and Oracle Text indexes.
  - You can store data that is in `XMLType` views in local or remote tables. You can access remote tables using database links.
- Support for XQuery, including XQuery Update and XQuery Full Text.
- Oracle XML DB Repository. You can store any kind of documents in the repository, including XML documents that are associated with an XML schema that is registered with Oracle XML DB. You can access documents in the repository in any of the following ways:
  - HTTP(S), through the HTTP protocol handler
  - WebDAV and FTP, through the WebDAV and FTP protocol handlers
  - SQL, through Oracle Net Services, including Java Database Connectivity (JDBC)

Figure 1–3 XMLType Storage



See Also:

- Part II, "Manipulation of XML Data in Oracle XML DB"
- Chapter 28, "Repository Access Using Protocols"
- Chapter 38, "XML Data Exchange Using Oracle Streams AQ"

Oracle XML DB Features

Any database used for managing XML must be able to persist XML documents. Oracle XML DB is capable of much more than this. It provides standard database features such as transaction control, data integrity, replication, reliability, availability, security,

and scalability, while also allowing for efficient indexing, querying, updating, and searching of XML documents in an XML-centric manner.

The hierarchical nature of XML presents the traditional relational database with some challenges:

- In a relational database, the *table-row* metaphor locates content. Primary-Key Foreign-Key relationships help define the relationships between content. Content is accessed and updated using the table-row-column metaphor.
- XML, on the other hand, uses *hierarchical* techniques to achieve the same functionality. A URL is used to locate an XML document. URL-based standards such as XLink are used to define relationships between XML documents. W3C Recommendations such as XPath are used to access and update content contained within XML documents. Both URLs and XPath expressions are based on *hierarchical* metaphors. A URL uses a path through a *folder hierarchy* to identify a document, whereas XPath uses a path through the *node hierarchy* of an XML document to access part of an XML document.

Oracle XML DB addresses these challenges by introducing SQL functions and methods that allow the use of XML-centric metaphors, such as XQuery and XPath expressions for querying and updating XML Documents.

The following sections describe the major features of Oracle XML DB:

- XMLType Data Type
- XMLType Storage Models
- XML Schema Support
- Static Data Dictionary Views Related to XML
- SQL/XML Standard Functions
- Programmatic Access to Oracle XML DB (Java, PL/SQL, and C)
- Oracle XML DB Repository: Overview

XMLType Data Type

Using `XMLType`, XML developers can leverage the power of XML standards while working in the context of a relational database, and SQL developers can leverage the power of a relational database while working with XML data.

`XMLType` is an abstract native SQL data type for XML data. It provides PL/SQL and Java constructors for creating an `XMLType` instance from a `VARCHAR2`, `CLOB`, `BLOB`, or `BFILE` instance. And it provides PL/SQL methods for various XML operations.

You can use `XMLType` as you would any other SQL data type. For example, you can create an `XMLType` table or view, or an `XMLType` column in a relational table.

You can use `XMLType` in PL/SQL stored procedures for parameters, return values, and variables.

You can also manipulate `XMLType` data using application programming interfaces (APIs) for the Java and C languages, including Java Database Connectivity (JDBC), XQuery for Java (XQJ), and Oracle Data Provider for .NET (ODP.NET).

`XMLType` is an Oracle Database *object* type, so you can also create a table of `XMLType` object instances. By default, an `XMLType` table or column can contain any well-formed XML document.

You can constrain XMLType tables or columns to conform to an XML schema, in which case the database ensures that only XML data that validates against the XML schema is stored in the column or table. invalid documents are excluded.

See Also:

- *Oracle Database Object-Relational Developer's Guide* for information about Oracle Database object types and object-relational storage
- *Oracle XML Developer's Kit Programmer's Guide* for information about using XQJ
- *Oracle Database PL/SQL Packages and Types Reference* for information about XMLType constructors and methods

XMLType Storage Models

XMLType is an *abstract* data type that provides different *storage models* to best fit your data and your use of it. As an abstract data type, your applications and database queries gain in flexibility: the same interface is available for all XMLType operations.

XMLType tables and columns can be stored in these ways:

- **Binary XML** storage (the default) – XMLType data is stored in a post-parse, binary format designed specifically for XML data. Binary XML is compact, post-parse, XML schema-aware XML data. This is also referred to as **post-parse persistence**.
- **Object-relational** storage – XMLType data is stored as a set of objects. This is also referred to as **structured** storage and **object-based persistence**.

Note: Starting with Oracle Database 12*c* Release 1 (12.1.0.1), the unstructured (CLOB) storage model for XMLType is *deprecated*. Use binary XML storage instead.

With the use of appropriate indexes, binary XML storage offers good performance for most use cases. However, some advanced use cases can benefit from using object-relational storage.

You can change XMLType storage from one model to another using database import/export. Your application code need not change. You can change XML storage options when tuning your application.

For binary XML storage, SecureFiles is the default storage option.[1] However, if either of the following is true then it is not possible to use SecureFiles LOB storage. In that case, BasicFiles is the default option for binary XML data:

- The tablespace for the XMLType table does not use automatic segment space management.
- A setting in file init.ora prevents SecureFiles LOB storage. For example, see parameter DB_SECUREFILE.

[1] Prior to Oracle Database 11*g* Release 2 (11.2.0.2) the BasicFiles option was the default for binary XML storage. Use of the BasicFiles option for binary XML data is *deprecated*.

See Also:

- Chapter 16, "Choice of XMLType Storage and Indexing"
- Chapter 37, "Export and Import of Oracle XML DB Data"
- *Oracle Database SQL Language Reference*, section "CREATE TABLE", clause "LOB_storage_clause"
- *Oracle Database SecureFiles and Large Objects Developer's Guide* for information about LOB storage options SecureFiles and BasicFiles
- *Oracle Database Administrator's Guide* for information about automatic segment space management
- *Oracle Database Reference* for information about parameter `DB_SECUREFILE`

XML Schema Support

Support for the Worldwide Web Consortium (W3C) XML Schema Recommendation is a key feature in Oracle XML DB. XML Schema specifies the structure, content, and certain semantics of XML documents. It is described in detail at `http://www.w3.org/TR/xmlschema-0/`.

The W3C Schema Working Group publishes a particular XML schema, often referred to as the **schema for schemas**, that provides the definition, or vocabulary, of the XML Schema language. An **XML schema definition** (**XSD**[2]), also called an **XML schema**, is an XML document that is compliant with the vocabulary defined by the schema for schemas.

An XML schema uses vocabulary defined by the schema for schemas to create a collection of XML Schema type definitions and element declarations that comprise a vocabulary for describing the contents and structure of a new class of XML documents, the **XML instance documents** that conform to that XML schema.

Note: This manual uses the term "XML schema" (lower-case "s") to reference any XML schema that conforms to the W3C XML Schema (upper-case "S") Recommendation. Since an XML schema is used to define a class of XML documents, the term "instance document" is often used to describe an XML document that conforms to a particular XML schema.

The XML Schema language provides strong typing of elements and attributes. It defines numerous scalar data types. This base set of data types can be extended to define more complex types, using object-oriented techniques such as inheritance and extension. The XML Schema vocabulary also includes constructs that you can use to define complex types, substitution groups, repeating sets, nesting, ordering, and so on. Oracle XML DB supports all of the constructs defined by the XML Schema Recommendation, except for `redefines`.

XML schemas are commonly used as a mechanism for checking (validating) whether XML instance documents conform with their specifications. Oracle XML DB includes `XMLType` methods and SQL functions that you can use to validate XML documents against an XML schema.

[2] `xsd` is the prefix used in the schema of schemas for the XML Schema namespace, hence it is also the namespace prefix used for the XML Schema data types, such as `xsd:string`. `xsd` is also used often as the file extension of XML schema files.

In Oracle XML DB, you can use a standard data model for all of your data, regardless of how structured it is. You can use XML Schema to automatically create database tables for storing your XML data. XML schema-based data maintains DOM fidelity and allows for significant database optimizations.

XML schema-based data can be stored using either Oracle XML DB `XMLType` storage model: binary XML storage or object-relational storage. Non-schema-based XML data can be stored only using binary XML storage.

You can also wrap existing relational and object-relational data as `XMLType` views, which can optionally be XML schema-based. You can map from incoming XML documents to `XMLType` storage, specifying the mapping using a registered XML schema.

See Also:

- Chapter 16, "Choice of XMLType Storage and Indexing" for information about `XMLType` storage models
- Chapter 17, "XML Schema Storage and Query: Basic" for more information about using XML schemas with Oracle XML DB

DTD Support in Oracle XML DB

This chapter is about using XML Schema with Oracle XML DB. An XML schema is in general a much more powerful way to define XML document structure than is a DTD. You can nevertheless use DTDs to some extent with Oracle XML DB.

Like an XML schema, A **DTD** is a set of rules that define the allowable structure of an XML document. DTDs are text files that derive their format from SGML. They can be associated with an XML document by using DTD element `DOCTYPE` or by using an external file through a `DOCTYPE` reference.

Oracle XML DB uses XML Schema, not DTDs, to define structured mappings to `XMLType` storage, but XML processors can still access and interpret your DTDs.

Note: You can use a DTD to obtain the XML entities defined in it. The entities are the only information used from the DTD. The structural and type information in the DTD is not used by Oracle XML DB.

Inline DTD Definitions

When an XML instance document has an inline DTD definition, it is used during document parsing. Any DTD validations and entity declaration handling is done at this point. However, once parsed, the entity references are replaced with actual values and the original entity reference is lost.

External DTD Definitions

Oracle XML DB also supports external DTD definitions if they are stored in Oracle XML DB Repository. Applications needing to process an XML document containing an external DTD definition such as `/public/flights.dtd` must first ensure that the DTD document is stored in Oracle XML DB at path `/public/flights.dtd`.

See Also: Chapter 21, "Accessing Oracle XML DB Repository Data"

Static Data Dictionary Views Related to XML

Table 1–1 lists the static data dictionary views related to XML. Information about a given view can be obtained by using SQL command `DESCRIBE`.

```
DESCRIBE USER_XML_SCHEMAS
```

Table 1–1 Static Data Dictionary Views Related to XML

Schema	Description
`USER_XML_SCHEMAS`	Registered XML schemas *owned* by the current *user*
`ALL_XML_SCHEMAS`	Registered XML schemas *usable* by the current *user*
`DBA_XML_SCHEMAS`	Registered XML schemas in Oracle XML DB
`USER_XML_TABLES`	`XMLType` tables *owned* by the current *user*
`ALL_XML_TABLES`	`XMLType` tables *usable* by the current *user*
`DBA_XML_TABLES`	`XMLType` tables in Oracle XML DB
`USER_XML_TAB_COLS`	`XMLType` table columns *owned* by the current *user*
`ALL_XML_TAB_COLS`	`XMLType` table columns *usable* by the current *user*
`DBA_XML_TAB_COLS`	`XMLType` table columns in Oracle XML DB
`USER_XML_VIEWS`	`XMLType` views *owned* by the current *user*
`ALL_XML_VIEWS`	`XMLType` views *usable* by the current *user*
`DBA_XML_VIEWS`	`XMLType` views in Oracle XML DB
`USER_XML_VIEW_COLS`	`XMLType` view columns *owned* by the current *user*
`ALL_XML_VIEW_COLS`	`XMLType` view columns *usable* by the current *user*
`DBA_XML_VIEW_COLS`	`XMLType` view columns in Oracle XML DB

In addition to the views `ALL_XML_TABLES`, `DBA_XML_TABLES`, and `USER_XML_TABLES`, views `ALL_OBJECT_TABLES`, `DBA_OBJECT_TABLES`, and `USER_OBJECT_TABLES` provide tablespace and other storage information for `XMLType` data stored object-relationally.

See Also:

- *Oracle Database Reference*
- *Oracle Database PL/SQL Packages and Types Reference*

SQL/XML Standard Functions

Oracle XML DB provides the SQL functions that are defined in the SQL/XML standard. SQL/XML functions fall into two groups:

- Functions that you can use to *generate* XML data from the result of a SQL query. In this book, these are called **SQL/XML publishing functions**. They are also sometimes called **SQL/XML generation functions**.
- Functions that you can use to *query* and *update* XML content as part of normal SQL operations. In this book, these are called **SQL/XML query and update functions**.

Using SQL/XML functions you can address XML content in any part of a SQL statement. These functions use XQuery or XPath expressions to traverse the XML structure and identify the nodes on which to operate. The ability to embed XQuery and XPath expressions in SQL statements greatly simplifies XML access.

See Also:

- *Oracle Database SQL Language Reference* for information about Oracle support for the SQL/XML standard
- Chapter 5, "Query and Update of XML Data" and Chapter 4, "XQuery and Oracle XML DB" for detailed descriptions of the SQL/XML standard functions for *querying* XML data
- Generation of XML Data Using SQL Functions on page 8-2 for information about SQL/XML standard functions for *generating* XML data
- Chapter 3, "Overview of How To Use Oracle XML DB" for additional examples that use SQL/XML standard functions
- "Standards Supported by Oracle XML DB" on page 1-17

Programmatic Access to Oracle XML DB (Java, PL/SQL, and C)

All Oracle XML DB functionality is accessible from C, PL/SQL, and Java. You can build Web-based applications in various ways, including these:

- Using servlets and Java Server Pages (JSP). A typical API accesses data using Java Database Connectivity (JDBC).
- Using Extensible Stylesheet Language (XSL) plus XML Server Pages (XSP). A typical API accesses data in the form of XML documents that are processed using a Document Object Model (DOM) API implementation.

Oracle XML DB supports such styles of application development. It provides Java, PL/SQL, and C implementations of the DOM API.

Applications that use JDBC, such as those based on servlets, need prior knowledge of the data structure they are processing. Oracle JDBC drivers allow you to access and update `XMLType` tables and columns, and call PL/SQL procedures that access Oracle XML DB Repository.

Applications that use DOM, such as those based on XSLT transformations, typically require less knowledge of the data structure. DOM-based applications use string names to identify pieces of content, and must dynamically walk through the DOM tree to find the required information. For this, Oracle XML DB supports the use of the DOM API to access and update `XMLType` columns and tables. Programming to a DOM API is more flexible than programming through JDBC, but it may require more resources at run time.

Oracle XML DB Repository: Overview

Oracle XML DB Repository is a component of Oracle Database that lets you handle XML data using a file/folder/URL metaphor. The repository contains **resources**, which can be either **folders** (directories, containers) or files.

A resource, whether folder or file, has these properties:

- It is identified by a *path* and *name*.
- It has *content* (data), which can be XML data but need not be.
- It has a set of **system-defined metadata** (properties), such as `Owner` and `CreationDate`, in addition to its content. Oracle XML DB uses this information to manage the resource.

- It might also have **user-defined metadata**. Like system-defined metadata, this is information that is not part of the content, but is associated with it.
- It has an associated **access control list** that determines who can access the resource, and for what operations.

Although Oracle XML DB Repository treats XML content specially, you can use the repository to store other kinds of data besides XML. You can use the repository to access any data that is stored in Oracle Database.

You can access data in the repository in the following ways:

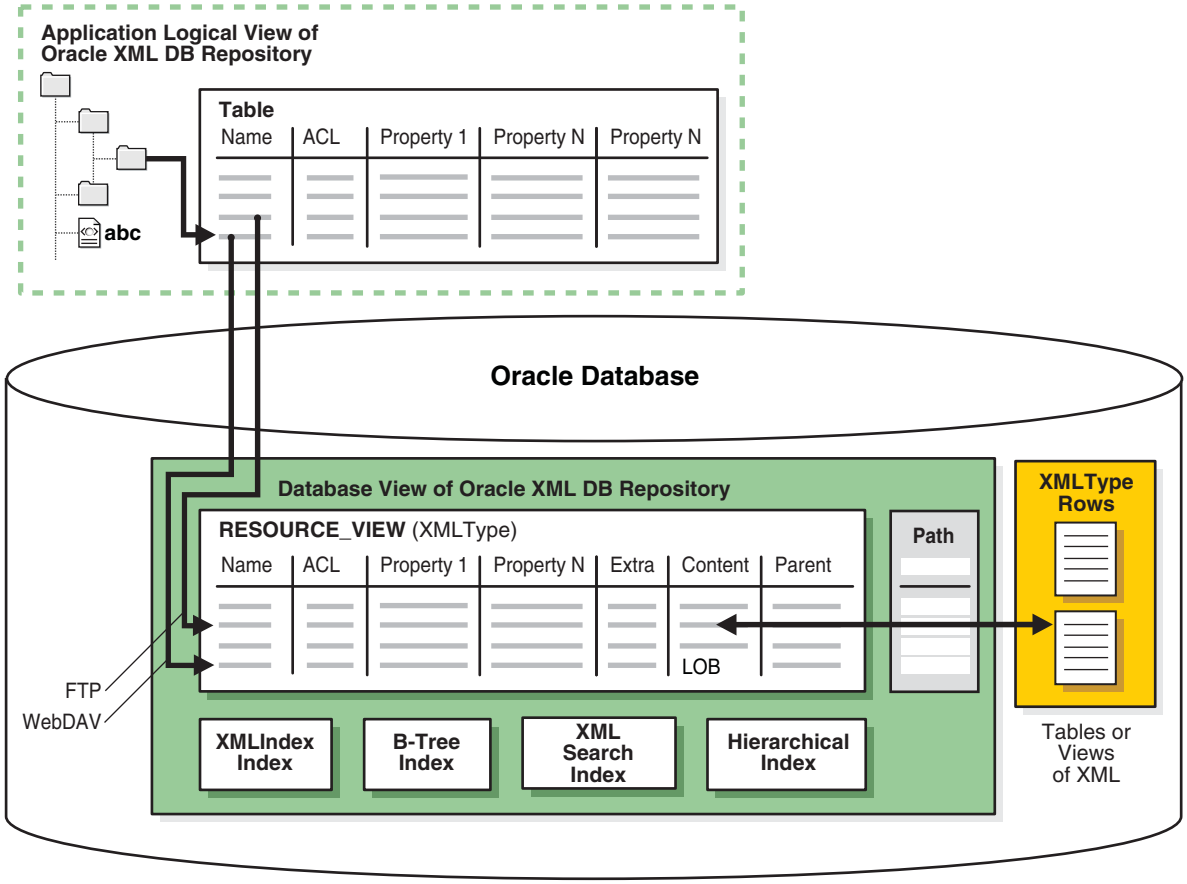
- SQL – Using views `RESOURCE_VIEW` and `PATH_VIEW`
- Standard protocols – FTP, HTTP(S), and WebDAV
- PL/SQL – Using PL/SQL package `DBMS_XDB_REPOS`
- Java – Using the Oracle XML DB resource API for Java

Besides providing APIs for accessing and manipulating repository data, Oracle XML DB provides APIs for the following repository services, which are based on IETF WebDAV:

- Versioning – Using PL/SQL package `DBMS_XDB_VERSION`
- ACL Security – Using access control lists (ACLs)
- Foldering – Using repository path names

Figure 1–4 illustrates the architecture of Oracle XML DB Repository.

Figure 1–4 Oracle XML DB Repository Architecture



See Also: Part VI, "Oracle XML DB Repository"

Standards Supported by Oracle XML DB

Oracle XML DB supports all major XML, SQL, Java, and Internet standards:

- W3C XML Schema 1.0 Recommendation. You can register XML schemas, validate stored XML content against XML schemas, or constrain XML stored in the server to XML schemas.
- W3C XQuery 1.0 Recommendation and W3C XPath 2.0 Recommendation. You can search or traverse XML stored inside the database using XQuery and XPath, either from HTTP(S) requests or from SQL.
- ANSI/ISO/IEC 9075-14:2011, Information technology—Database languages—SQL—Part 14: XML-Related Specifications (SQL/XML).
- W3C DOM Recommendation Levels 1.0 and 2.0 Core. You can retrieve XML stored in the server as an XML DOM, for dynamic access.
- Java Database Connectivity (JDBC) API. Provides Java access to XML data.
- XQuery API for Java (XQJ). Provides Java access to XML data using XQuery.
- W3C XSL 1.0 Recommendation. You can transform XML documents at the server using XSLT.

- Protocol support. You can store or retrieve XML data from Oracle XML DB using Oracle Net or standard protocols such as HTTP(S), FTP, and IETF WebDAV.
- Java Servlet version 2.2, (except: the servlet WAR file, `web.xml`, is not supported in its entirety; only one `ServletContext`; one `web-app` are currently supported; and stateful servlets are not supported).
- Web services: SOAP 1.1. You can access XML stored in the server from SOAP requests. You can build, publish, or find Web Services using Oracle XML DB and Oracle Fusion Middleware, using WSDL and UDDI. You can use Oracle Streams Advanced Queuing IDAP, the SOAP specification for queuing operations, on XML stored in Oracle Database.
- W3C XML Linking Language (Xlink) 1.0 Recommendation. You can define various types of links between XML documents.
- W3C XML Pointer Language (XPointer) Recommendation and XPointer Framework. You can include the content of multiple XML documents or fragments in a single infoset.

See Also:

- "SQL/XML Standard Functions" on page 1-14 for more information about the SQL/XML functions
- *Oracle XML Developer's Kit Programmer's Guide* for information about using XQJ
- *Oracle Database SQL Language Reference* for information about Oracle support for the SQL/XML standard
- Chapter 23, "How To Use XLink and XInclude with Oracle XML DB" for more information about XLink and XPointer support
- Chapter 28, "Repository Access Using Protocols" for more information about protocol support
- Chapter 32, "How to Write Oracle XML DB Applications in Java" for information about using the Java servlet
- Chapter 38, "XML Data Exchange Using Oracle Streams AQ" and *Oracle Database Advanced Queuing User's Guide* for information about using SOAP

Oracle XML DB Technical Support

Besides your regular channels of support through your customer representative or consultant, technical support for Oracle Database XML-enabled technologies is available free through the Discussion Forums section of Oracle Technology Network (OTN):

`http://forums.oracle.com/forums/category.jspa?categoryID=51`

Oracle XML DB Examples Used in This Manual

This manual contains examples that illustrate the use of Oracle XML DB and `XMLType`. The examples are based on various database schemas, sample XML documents, and sample XML schemas.

See Also: Appendix A, "Oracle-Supplied XML Schemas and Examples"

Further Oracle XML DB Case Studies and Demonstrations

Visit OTN to view Oracle XML DB examples, white papers, case studies, and demonstrations:

http://www.oracle.com/technetwork/database-features/xmldb/overview/index.html

Comprehensive XML classes on how to use Oracle XML DB are also available. See the Oracle University link on OTN.

Some detailed Oracle XML DB case studies are available on OTN and include the following:

- Oracle XML DB Downloadable Demonstration. This detailed demonstration illustrates how to use many Oracle XML DB features. Parts of this demonstration are also included in Chapter 3, "Overview of How To Use Oracle XML DB".
- SAX Loader Application. This demonstrates an efficient way to break up large files containing multiple XML documents outside the database and insert them into the database as a set of separate documents. This is provided as a standalone and a Web-based application.

2

Getting Started with Oracle XML DB

This chapter provides some preliminary design criteria for consideration when planning your Oracle XML DB solution.

This chapter contains these topics:

- Oracle XML DB Installation
- Oracle XML DB Use Cases
- Application Design Considerations for Oracle XML DB

Oracle XML DB Installation

Oracle XML DB is installed automatically if Database Configuration Assistant (DBCA) is used to build Oracle Database using the general-purpose template.

You can determine whether or not Oracle XML DB is already installed. If it is installed, then the following are true:

- Database schema (user account) `XDB` exists. To check that, run this query:

  ```
  SELECT * FROM ALL_USERS;
  ```

- View `RESOURCE_VIEW` exists. To check that, use this command:

  ```
  DESCRIBE RESOURCE_VIEW
  ```

See Also:

- Chapter 35, "Administration of Oracle XML DB" for information about installing Oracle XML DB *manually*
- *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

Oracle XML DB Use Cases

Oracle XML DB is suited for any application where some or all of the data processed by the application is represented using XML. Oracle XML DB provides for high-performance database ingestion, storage, processing and retrieval of XML data. It also lets you quickly and easily generate XML from existing relational data.

Applications for which Oracle XML DB is particularly suited include the following:

- Business-to-business (B2B) and application-to-application (A2A) integration
- Internet
- Content-management

- Messaging
- Web Services

A typical Oracle XML DB application has at least one of the following characteristics:

- Large numbers of XML documents must be ingested or generated
- Large XML documents must be processed or generated
- High-performance searching is needed, both within a document and across large collections of documents
- High levels of security are needed
- Fine-grained security is needed
- Data processing must use XML documents, and data must be stored in relational tables
- Programming must support open standards such as SQL, XML, XQuery, XPath, and XSL
- Information must be accessed using standard Internet protocols such as FTP, HTTP(S)/WebDAV, and Java Database Connectivity (JDBC)
- XML data must be queried from SQL
- Analytic capabilities must be applied to XML data
- XML documents must be validated against an XML schema

Application Design Considerations for Oracle XML DB

This section describes some preliminary design criteria that you can consider when planning your Oracle XML DB application. However, Oracle recommends that you start with the following Oracle XML DB features. For most use cases they are all that you need to consider.

- Storage model – binary XML
- Indexing – XML search index, `XMLIndex` with structured component
- Database language – SQL, with SQL/XML functions
- XML languages – XQuery and XSLT
- Client APIs – OCI, thin JDBC, SQL .NET

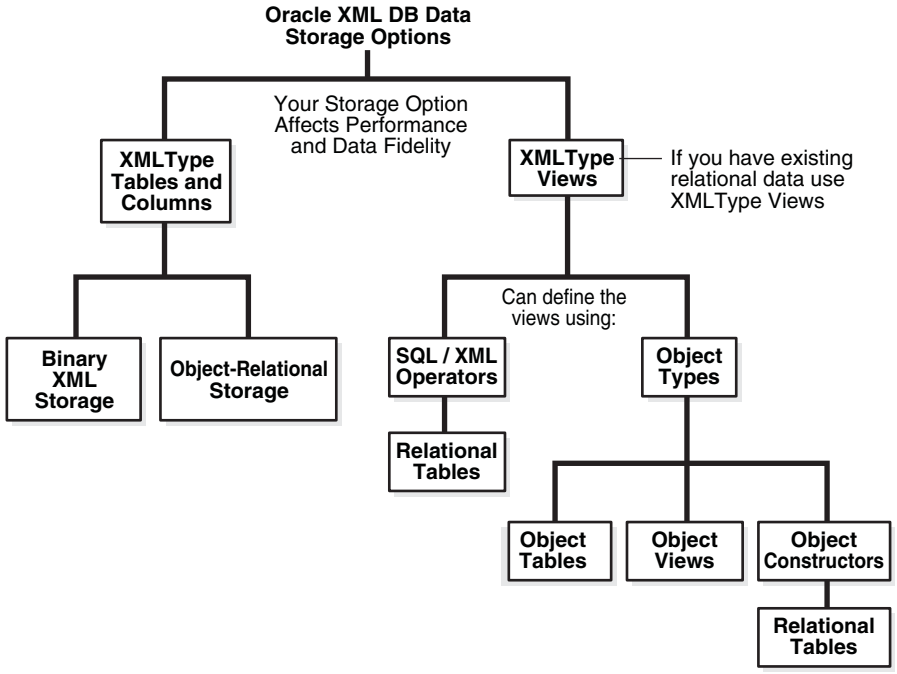
See Also:

- Chapter 16, "Choice of XMLType Storage and Indexing"
- "SQL/XML Standard Functions" on page 1-14
- Chapter 4, "XQuery and Oracle XML DB"
- Chapter 7, "Transformation and Validation of XMLType Data"
- Chapter 14, "The C API for XML"
- Chapter 13, "Java DOM API for XMLType"
- Chapter 15, "Oracle XML DB and Oracle Data Provider for .NET"

XML Data Storage

There are various ways to store XML data in Oracle Database. Storage of `XMLType` tables and views is outlined in Figure 2–1.

Figure 2–1 Oracle XML DB Storage Options for XML Data



If you have existing relational data, you can access it as XML data by creating `XMLType` views over it. You can use the following to define the `XMLType` views:

- SQL/XML functions. See Chapter 8, "Generation of XML Data from Relational Data" and Chapter 4, "XQuery and Oracle XML DB".
- Object types: object tables, object constructors, and object views.

Regardless of which storage options you choose for your application, Oracle XML DB provides the same functionality. Though the storage model you use can affect your application performance and XML data fidelity, it is totally independent of how frequently you query or update your data and what APIs your application uses.

See Also: "XMLType Storage Models" on page 1-11

Structure of Your XML Data

If your XML data is *not* XML Schema-based, then, regardless of how structured it is, you can store it in an `XMLType` table or view as binary XML, or you can store it as a file in an Oracle XML DB Repository folder. You cannot store it object-relationally.

If your XML data is XML Schema-based then you must store it as binary XML or object-relationally.

See Also: Chapter 16, "Choice of XMLType Storage and Indexing"

Application Language

You can program your Oracle XML DB applications in the following languages:

- Java (JDBC, Java Servlets)

  See Also:

  - Chapter 13, "Java DOM API for XMLType"
  - Chapter 32, "How to Write Oracle XML DB Applications in Java"

- PL/SQL

  See Also:

  - Chapter 11, "PL/SQL APIs for XMLType"
  - Chapter 26, "PL/SQL Access to Oracle XML DB Repository"

XML Processing Options

The following processing options are available and should be considered when designing your Oracle XML DB application:

- XML Generation and `XMLType` views. Whether you need to generate (or regenerate) XML data. See Chapter 8, "Generation of XML Data from Relational Data".
- Whether your application is data-centric or document-centric, or both. See Chapter 3, "Overview of How To Use Oracle XML DB".
- DOM fidelity, document fidelity. `XMLType` storage, whether object-relational or binary XML, preserves *DOM fidelity*. That is, A DOM created from an XML document stored as `XMLType` is identical to a DOM created from the original document. However, there could be differences in insignificant whitespace. See "DOM Fidelity" on page 17-6, "SYS_XDBPD$ and DOM Fidelity for Object-Relational Storage" on page 18-5, and Chapter 11, "PL/SQL APIs for XMLType".

  If you need to preserve *document fidelity* (insignificant whitespace) in addition to DOM fidelity, then store two copies of your original document: one as an `XMLType` instance for database use and XML processing, the other as a `CLOB` instance to provide document fidelity.
- XPath searching. You can use XPath syntax embedded in a SQL statement to query XML content in the database. See Chapter 5, "Query and Update of XML Data", Chapter 21, "Accessing Oracle XML DB Repository Data", Chapter 24, "Repository Access Using RESOURCE_VIEW and PATH_VIEW", and Appendix E, "Full-Text Search over XML Data Without XQuery".
- How often XML documents are accessed, updated, and manipulated. See Chapter 5, "Query and Update of XML Data".
- Whether you need to update fragments or whole documents. You can use XPath expressions to specify individual elements and attributes of your document during updates, without rewriting the entire document. This is more efficient, especially for large XML documents. See "Updating XML Data" on page 5-26.
- Which kinds of indexing best suit your application and data. See Chapter 6, "Indexes for XMLType Data" and Appendix E, "Full-Text Search over XML Data Without XQuery".
- XSLT. Whether you need to transform the XML data to HTML, WML, or other languages, and, if so, how your application does this. While storing XML

documents in Oracle XML DB, you can optionally ensure that their structure complies with (validates against) specific XML schemas. See Chapter 7, "Transformation and Validation of XMLType Data".

Oracle XML DB Repository Access

This section pertains to data that is stored as resources in Oracle XML DB Repository.

There are two main repository access methods:

- Navigation-based access or path-based access. This is suitable for both content/document and data oriented applications. Oracle XML DB provides the following languages and access APIs:
  - SQL access through resource and path views. See Chapter 24, "Repository Access Using RESOURCE_VIEW and PATH_VIEW".
  - PL/SQL access using package `DBMS_XDB` or packages `DBMS_XDB_ADMIN`, `DBMS_XDB_CONFIG` and `DBMS_XDB_REPOS`. See Chapter 26, "PL/SQL Access to Oracle XML DB Repository".
  - Protocol-based access using HTTP(S)/WebDAV or FTP, most suited to content-oriented applications. See Chapter 28, "Repository Access Using Protocols".
- Query-based access. This can be most suited to data oriented applications. Oracle XML DB provides access using SQL queries through the following APIs:
  - Java access (through JDBC). See Java DOM API for XMLType.
  - PL/SQL access. See Chapter 11, "PL/SQL APIs for XMLType".

These options for accessing repository data are also discussed in Chapter 21, "Accessing Oracle XML DB Repository Data".

You can also consider the following access criteria:

- What levels of security you need. See Chapter 27, "Repository Access Control".
- Whether you need to version the data. See Chapter 25, "Resource Versions".

Oracle XML DB Cooperates with Other Database Options and Features

Oracle XML DB is an integrated part of Oracle Database, and works well with other database options and features, including the following.

- Oracle Streams Advanced Queuing (AQ) – merge XML payloads. See Chapter 38, "XML Data Exchange Using Oracle Streams AQ" and *Oracle Database Advanced Queuing User's Guide*
- Oracle GoldenGate and Oracle Active Data Guard – replicate and safeguard XML data, or perform a rolling upgrade. See *Oracle GoldenGate* and *Oracle Data Guard Concepts and Administration*
- Oracle Exadata Storage Server Software – high-performance, scalable, and highly available use of XML data. See *Oracle Database High Availability Overview*
- Oracle Real Application Clusters (Oracle RAC) – Use XML data with clusters of database instances. See *Oracle Real Application Clusters Administration and Deployment Guide*
- Oracle Multitenant option – Use XML data with a multitenant architecture, where each pluggable database has its own Oracle XML DB Repository. See *Oracle Database Concepts*

- Compression and Encryption – You can compress or encrypt binary XML data that uses SecureFiles LOB storage. For XML data stored object-relationally, you can compress or encrypt XML elements and attributes individually.
- Parallel Execution – Execution of the following operations can be carried out in parallel:
  - A query of `XMLType` data
  - DML for `XMLType` data stored as binary XML using SecureFiles LOBs
  - A direct load for an `XMLType` table on which an Oracle Text `CONTEXT` index is defined

See Also: *Oracle Database Concepts*

3

Overview of How To Use Oracle XML DB

This chapter is an overview of how to use Oracle XML DB.

Many of the examples presented in this chapter illustrate techniques for accessing and managing XML content in purchase-order documents. Purchase orders are highly structured documents, but you can also use the techniques shown here to work with XML documents that have little structure.

The purchase-order documents used for the examples here conform to a purchase-order XML schema that demonstrates some key features of a typical XML document:

- Global element `PurchaseOrder` is an instance of the `complexType` `PurchaseOrderType`
- `PurchaseOrderType` defines the set of nodes that make up a `PurchaseOrder` element
- `LineItems` element consists of a collection of `LineItem` elements
- Each `LineItem` element consists of two elements: `Description` and `Part`
- `Part` element has attributes `Id`, `Quantity`, and `UnitPrice`

This chapter contains these topics:

Creating XMLType Tables and Columns

`XMLType` is an abstract data type, so it is straightforward to create an `XMLType` table or column. The basic `CREATE TABLE` statement, specifying no storage options and no XML schema, stores `XMLType` data as binary XML.[1]

Example 3–1 creates an `XMLType` column, and Example 3–2 creates an `XMLType` table.

Example 3–1 Creating a Table with an XMLType Column

```
CREATE TABLE mytable1 (key_column VARCHAR2(10) PRIMARY KEY, xml_column XMLType);
```

Example 3–2 Creating a Table of XMLType

```
CREATE TABLE mytable2 OF XMLType;
```

See Also: "Creating XMLType Tables and Columns Based on XML Schemas" on page 17-16

Creating Virtual Columns on XMLType Data Stored as Binary XML

You can create virtual columns only for XMLType data that is stored as binary XML. Such columns are useful for partitioning or constraining the data.

You create virtual columns for XML data the same way you create them for other data types, but you use a slightly different syntax. (In particular, you cannot specify constraints in association with the column definition.)

You create a virtual column based on an XML element or attribute by defining it in terms of a SQL expression that involves that element or attribute. The column is thus function-based.

You use SQL/XML functions XMLCast and XMLQuery to do this, as shown in Example 3–3 and Example 3–4. The XQuery expression argument to function XMLQuery must be a simple XPath expression that uses only the child and attribute axes.

Example 3–3 creates XMLType table po_binaryxml, stored as binary XML. It creates virtual column date_col, which represents the XML data in attribute /PurchaseOrder/@orderDate.

Example 3–3 Creating a Virtual Column for an XML Attribute in an XMLType Table

```
CREATE TABLE po_binaryxml OF XMLType
  XMLTYPE STORE AS BINARY XML
  VIRTUAL COLUMNS
    (date_col AS (XMLCast(XMLQuery('/PurchaseOrder/@orderDate'
                                   PASSING OBJECT_VALUE RETURNING CONTENT)
                          AS DATE)));
```

Example 3–4 creates relational table rel_tab, which has two columns: VARCHAR2 column key_col for the primary key, and XMLType column xml_col for the XML data.

Example 3–4 Creating a Virtual Column for an XML Attribute in an XMLType Column

```
CREATE TABLE reltab (key_col VARCHAR2(10) PRIMARY KEY,
                     xml_col XMLType)
  XMLTYPE xml_col STORE AS BINARY XML
  VIRTUAL COLUMNS
    (date_col AS (XMLCast(XMLQuery('/PurchaseOrder/@orderDate'
                                   PASSING xml_col RETURNING CONTENT)
                          AS DATE)));
```

Because XMLType is an abstract data type, if you create virtual columns on an XMLType table or column then those columns are *hidden*. They do not show up in DESCRIBE

[1] The XMLType storage model for XML schema-based data is whatever was specified during registration of the referenced XML schema. If no storage model was specified during registration, then object-relational storage is used.

statements, for example. This hiding enables tools that use operations such as `DESCRIBE` to function normally and not be misled by the virtual columns.

See Also:

- "Partitioning Tables That Contain XMLType Data Stored as Binary XML" on page 3-3
- "Enforcing Referential Integrity Using SQL Constraints" on page 3-5
- *Oracle Database SQL Language Reference* for information about creating tables with virtual columns

Partitioning Tables That Contain XMLType Data Stored as Binary XML

You can partition a table that contains `XMLType` data stored as binary XML. There are two cases:

- The table is relational, with an `XMLType` column and a non-`XMLType` column.
- The table is of data type `XMLType`.

In the case of an `XMLType` column, you use the non-`XMLType` column as the partitioning key. This is illustrated in Example 3–5.

Example 3–5 Partitioning a Relational Table That Has an XMLType Column

```
CREATE TABLE reltab (key_col VARCHAR2(10) PRIMARY KEY,
                     xml_col XMLType)
  XMLTYPE xml_col STORE AS BINARY XML
  PARTITION BY RANGE (key_col)
    (PARTITION P1 VALUES LESS THAN ('abc'),
     PARTITION P2 VALUES LESS THAN (MAXVALUE));
```

This case presents nothing new or specific with respect to XML data. The fact that one of the columns contains `XMLType` data is irrelevant. Things are different for the other case: partitioning an `XMLType` table.

XML data has its own structure, which (except for object-relational storage of `XMLType`) is not reflected directly in database data structure. For `XMLType` data stored as binary XML, individual XML elements and attributes are not mapped to individual database columns or tables.

Therefore, to partition binary XML data according to the values of individual elements or attributes, the standard approach for relational data does not apply. Instead, you must create *virtual columns* that represent the XML data of interest, and then use those virtual columns to define the constraints or partitions that you need.

The technique is as follows:

1. Define virtual columns that correspond to the XML elements or attributes that you are interested in.
2. Use those columns to partition the `XMLType` data as a whole.

This is illustrated in Example 3–6: virtual column `date_col` targets the `orderDate` attribute of element `PurchaseOrder` in a purchase-order document. This column is used as the partitioning key.

Example 3–6 Partitioning an XMLType Table

```
CREATE TABLE po_binaryxml OF XMLType
```

```
XMLTYPE STORE AS BINARY XML
VIRTUAL COLUMNS
  (date_col AS (XMLCast(XMLQuery('/PurchaseOrder/@orderDate'
                                 PASSING OBJECT_VALUE RETURNING CONTENT)
                        AS DATE)))
PARTITION BY RANGE (date_col)
  (PARTITION orders2001 VALUES LESS THAN (to_date('01-JAN-2002')),
   PARTITION orders2002 VALUES LESS THAN (MAXVALUE));
```

For best performance using a partitioned table containing XML data, Oracle recommends that you use an `XMLType` column rather than an `XMLType` table, and you therefore partition using a non-`XMLType` column.

Note:

- You can partition an `XMLType` table using a virtual column only if the storage model is binary XML. Range, hash, and list partitioning are supported.
- Partitioning of `XMLType` tables stored as XML is supported starting with 11g Release 2 (11.2). It is supported only if the database compatibility (parameter `compatible` in file `init.ora`) is 11.2 or higher.
- If a relational table has an `XMLType` *column*, you cannot partition the table using that column to define virtual columns of XML data.

See Also:

- "XMLIndex Partitioning and Parallelism" on page 6-36
- "Partitioning of XMLType Tables and Columns Stored Object-Relationally" on page 18-30

Enforcing XML Data Integrity Using the Database

One advantage of using Oracle XML DB to manage XML content is that SQL can be used to supplement the functionality provided by XML schema. Combining the power of SQL and XML with the ability of the database to enforce rules makes the database a powerful framework for managing XML content.

Only well-formed XML documents can be stored in `XMLType` tables or columns. A **well-formed** XML document is one that conforms to the syntax of the XML version declared in its XML declaration. This includes having a single root element, properly nested tags, and so forth. Additionally, if the `XMLType` table or column is constrained to an XML schema then only documents that conform to that XML schema can be stored in that table or column. Any attempt to store or insert any other kind of XML document in an XML schema-based `XMLType` raises an error. Example 3–7 illustrates this.

Example 3–7 Error From Attempting to Insert an Incorrect XML Document

```
INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'Invoice.xml'), nls_charset_id('AL32UTF8')))
  VALUES (XMLType(bfilename('XMLDIR', 'Invoice.xml'), nls_charset_id('AL32UTF8')))
          *
ERROR at line 2:
```

```
ORA-19007: Schema - does not match expected
http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd.
```

Such an error occurs only when content is inserted directly into an XMLType table. It indicates that Oracle XML DB did not recognize the document as a member of the class defined by the XML schema. For a document to be recognized as a member of the class defined by the schema, the following conditions must be true:

- The name of the XML document root element must match the name of global element used to define the XMLType table or column.
- The XML document must include the appropriate attributes from the XMLSchema-instance namespace, or the XML document must be explicitly associated with the XML schema using the XMLType constructor or XMLType method createSchemaBasedXML().

If the constraining XML schema declares a targetNamespace, then the instance documents must contain the appropriate namespace declarations to place the root element of the document in the targetNamespace defined by the XML schema.

Note: XML constraints are enforced only within individual XML documents. Database (SQL) constraints are enforced across sets of XML documents.

See Also: "Partial and Full XML Schema Validation" on page 7-12

Enforcing Referential Integrity Using SQL Constraints

The W3C XML Schema Recommendation defines a powerful language for defining the contents of an XML document. However, there are some simple data management concepts that are not currently addressed by the W3C XML Schema Recommendation. These include the ability to ensure that the value of an element or attribute has either of these properties:

- It is unique across a set of XML documents (a UNIQUE constraint).
- It exists in a particular data source that is outside of the current document (FOREIGN KEY constraint).

With Oracle XML DB, however, you can enforce such constraints. The mechanisms that you use to enforce integrity on XML data are the same as those you use to enforce integrity on relational data. Simple rules, such as uniqueness and foreign-key relationships, can be enforced by specifying SQL constraints. More complex rules can be enforced by specifying database triggers.

Oracle XML DB lets you use the database to enforce business rules on XML content, in addition to enforcing rules that can be specified using XML Schema constructs. The database enforces these business rules regardless of whether XML is inserted directly into a table or uploaded using one of the protocols supported by Oracle XML DB Repository.

XML data has its own structure, which (except for object-relational storage of XMLType) is not reflected directly in database data structure. For XMLType data stored as binary XML, individual XML elements and attributes are not mapped to individual database columns or tables.

Therefore, to constrain binary XML data according to the values of individual elements or attributes, the standard approach for relational data does not apply.

Instead, you must create *virtual columns* that represent the XML data of interest, and then use those virtual columns to define the constraints that you need.

The technique is as follows:

1. Define virtual columns that correspond to the XML elements or attributes that you are interested in.
2. Use those columns to constrain the `XMLType` data as a whole.

The binary XML data can be in an `XMLType` table or an `XMLType` column of a relational table. In the former case, you can include creation of the constraint as part of the `CREATE TABLE` statement, if you like. For the latter case, you must create the constraint using an `ALTER TABLE` statement, after the relational table has been created.

Example 3–8 illustrates this technique for an `XMLType` table. It defines virtual column `c_xtabref` using the `Reference` element in a purchase-order document. It defines uniqueness constraint `reference_is_unique` on that column, which ensures that the value of node `/PurchaseOrder/Reference/text()` is unique across all documents that are stored in the table. It fills the table with the data from `OE.purchaseorder`. It then tries to insert a duplicate document, `DuplicateReference.xml`, which violates the uniqueness constraint, raising an error.

Example 3–8 Constraining a Binary XML Table Using a Virtual Column

```
CREATE TABLE po_binaryxml OF XMLType
  (CONSTRAINT reference_is_unique UNIQUE (c_xtabref))
  XMLTYPE STORE AS BINARY XML
  VIRTUAL COLUMNS
    (c_xtabref AS (XMLCast(XMLQuery('/PurchaseOrder/Reference'
                                    PASSING OBJECT_VALUE RETURNING CONTENT)
                           AS VARCHAR2(32))));

INSERT INTO po_binaryxml SELECT OBJECT_VALUE FROM OE.purchaseorder;

132 rows created.

INSERT INTO po_binaryxml
  VALUES (XMLType(bfilename('XMLDIR', 'DuplicateReference.xml'),
                  nls_charset_id('AL32UTF8')));
INSERT INTO po_binaryxml
*
ERROR at line 1:
ORA-00001: unique constraint (OE.REFERENCE_IS_UNIQUE) violated
```

Example 3–9 illustrates the technique for an `XMLType` column of a relational table. It defines virtual column `c_xcolref` and uniqueness constraint `fk_ref`, which references the uniqueness constraint defined in Example 3–8. As in Example 3–8, this ensures that the value of node `/PurchaseOrder/Reference/text()` is unique across all documents that are stored in `XMLType` column `po_binxml_col`.

Example 3–9 fills the `XMLType` column with the same data from `OE.purchaseorder`. It then tries to insert duplicate document, `DuplicateReference.xml`, which violates the uniqueness constraint, raising an error.

Example 3–9 Constraining a Binary XML Column Using a Virtual Column: Uniqueness

```
CREATE TABLE po_reltab (po_binxml_col XMLType)
  XMLTYPE po_binxml_col STORE AS BINARY XML
  VIRTUAL COLUMNS
    (c_xcolref AS (XMLCast (XMLQuery('/PurchaseOrder/Reference'
```

```
                                    PASSING po_binxml_col RETURNING CONTENT)
                            AS VARCHAR2(32))));

ALTER TABLE po_reltab ADD CONSTRAINT reference_is_unique UNIQUE (c_xcolref));

INSERT INTO po_reltab SELECT OBJECT_VALUE FROM OE.purchaseorder;
INSERT INTO po_reltab
  VALUES (XMLType(bfilename('XMLDIR', 'DuplicateReference.xml'),
                  nls_charset_id('AL32UTF8')));
INSERT INTO po_reltab
*
ERROR at line 1:
ORA-00001: unique constraint (OE.REFERENCE_IS_UNIQUE) violated
```

Example 3–10 is similar to Example 3–9, but it uses a foreign-key constraint, `fk_ref`, which references the column with the uniqueness constraint defined in Example 3–8. Insertion of the document in file `DuplicateReference.xml` succeeds here, since that document is in (virtual) column `c_tabref` of table `po_binaryxml`. Insertion of a document that does not match any document in table `po_binaryxml`.

Example 3–10 Constraining a Binary XML Column Using a Virtual Column: Foreign Key

```
CREATE TABLE po_reltab (po_binxml_col XMLType)
  XMLTYPE po_binxml_col STORE AS BINARY XML
  VIRTUAL COLUMNS
    (c_xcolref AS (XMLCast (XMLQuery('/PurchaseOrder/Reference'
                                    PASSING po_binxml_col RETURNING CONTENT)
                            AS VARCHAR2(32))));

ALTER TABLE po_reltab ADD CONSTRAINT fk_ref FOREIGN KEY (c_xcolref)
                                           REFERENCES po_binaryxml(c_xtabref);

INSERT INTO po_reltab
  VALUES (XMLType(bfilename('XMLDIR', 'DuplicateReference.xml'),
                  nls_charset_id('AL32UTF8')));

INSERT INTO po_reltab
  VALUES ('<PurchaseOrder><Reference>Not Compliant</Reference></PurchaseOrder>');
INSERT INTO po_reltab VALUES ('<PurchaseOrder><Reference>Not Compliant
</Reference></PurchaseOrder>')
*
ERROR at line 1:
ORA-02291: integrity constraint (OE.FK_REF) violated - parent key not found
```

Integrity rules defined using constraints and triggers are also enforced when XML schema-based XML content is loaded into Oracle XML DB Repository. Example 3–11 illustrates this. It shows that database integrity is also enforced when a protocol, such as FTP, is used to upload XML schema-based XML content into Oracle XML DB Repository. In this case, additional constraints, besides uniqueness, were also violated.

Example 3–11 Enforcing Database Integrity When Loading XML Using FTP

```
$ ftp localhost 2100
Connected to localhost.
220 mdrake-sun FTP Server (Oracle XML DB/Oracle Database 10g Enterprise Edition
Release 10.1.0.0.0 - Beta) ready.
Name (localhost:oracle10): QUINE
331 Password required for QUINE
Password: password
230 QUINE logged in
```

```
ftp> cd /source/schemas
250 CWD Command successful
ftp> put InvalidReference.xml
200 PORT Command successful
150 ASCII Data Connection
550- Error Response
ORA-00604: error occurred at recursive SQL level 1
ORA-31154: invalid XML document
ORA-19202: Error occurred in XML processing
LSX-00221: "SBELL-20021009" is too short (minimum length is 18)
ORA-06512: at "SYS.XMLTYPE", line 333
ORA-06512: at "QUINE.VALIDATE_PURCHASEORDER", line 3
ORA-04088: error during execution of trigger 'QUINE.VALIDATE_PURCHASEORDER'
550 End Error Response
ftp> put InvalidElement.xml
200 PORT Command successful
150 ASCII Data Connection
550- Error Response
ORA-30937: No schema definition for 'UserName' (namespace '##local') in parent
'PurchaseOrder'
550 End Error Response
ftp> put DuplicateReference.xml
200 PORT Command successful
150 ASCII Data Connection
550- Error Response
ORA-00604: error occurred at recursive SQL level 1
ORA-00001: unique constraint (QUINE.REFERENCE_IS_UNIQUE) violated
550 End Error Response
ftp> put InvalidUser.xml
200 PORT Command successful
150 ASCII Data Connection
550- Error Response
ORA-00604: error occurred at recursive SQL level 1
ORA-02291: integrity constraint (QUINE.USER_IS_VALID) violated - parent key not
 found
550 End Error Response
```

When an error occurs while a document is being uploaded using a protocol, Oracle XML DB provides the client with the full SQL error trace. How the error is interpreted and reported to you is determined by the error-handling built into the client application. Some clients, such as a command line FTP tool, report the error returned by Oracle XML DB, while others, such as Microsoft Windows Explorer, report a generic error message.

See also:

- "Specifying Relational Constraints on XMLType Tables and Columns" on page 18-33
- "Creating Virtual Columns on XMLType Data Stored as Binary XML" on page 3-2
- *Oracle Database Error Messages*

Loading XML Content into Oracle XML DB

You can load XML content into Oracle XML DB using these techniques:

- Table-based loading:
  - Loading XML Content Using SQL or PL/SQL

- Loading XML Content Using Java
- Loading XML Content Using C
- Loading Large XML Files that Contain Small XML Documents
- Loading Large XML Files Using SQL*Loader

- Path-based repository loading techniques:
  - Loading XML Documents into the Repository Using DBMS_XDB_REPOS
  - Loading Documents into the Repository Using Protocols

Loading XML Content Using SQL or PL/SQL

You can use a simple `INSERT` operation in SQL or PL/SQL to load an XML document into the database. Before the document can be stored as an `XMLType` column or table, you must convert it into an `XMLType` instance using one of the `XMLType` constructors.

See Also:

- Chapter 5, "Query and Update of XML Data"
- "PL/SQL APIs for XMLType: References" on page 11-3
- *Oracle Database PL/SQL Packages and Types Reference* for a description of the `XMLType` constructors

`XMLType` **constructors** allow an `XMLType` instance to be created from different sources, including `VARCHAR`, `CLOB`, and `BFILE` values. The constructors accept additional arguments that reduce the amount of processing associated with `XMLType` creation. For example, if you are sure that a given source XML document is valid, you can provide an argument to the constructor that disables the type-checking that is otherwise performed.

In addition, if the source data is not encoded in the database character set, an `XMLType` instance can be constructed using a `BFILE` or `BLOB` value. The encoding of the source data is specified through the character set id (`csid`) argument of the constructor.

Example 3–13 shows how to insert XML content into an `XMLType` table. Before making this insertion, you must create a database directory object that points to the directory containing the file to be processed. To do this, you must have the `CREATE ANY DIRECTORY` privilege.

See Also: *Oracle Database SQL Language Reference*, under `GRANT`

Example 3–12 Creating a Database Directory

```
CREATE DIRECTORY xmldir AS path_to_folder_containing_XML_file;
```

Example 3–13 Inserting XML Content into an XMLType Table

```
INSERT INTO mytable2 VALUES (XMLType(bfilename('XMLDIR', 'purchaseOrder.xml'),
                                     nls_charset_id('AL32UTF8')));
```

The value passed to `nls_charset_id` indicates that the encoding for the file to be read is UTF-8.

When you use SQL `INSERT` to insert a large document containing collections into `XMLType` tables (but not into `XMLType` columns), Oracle XML DB optimizes load time and memory usage.

See Also: "Considerations for Loading and Retrieving Large Documents with Collections" on page 18-53

Loading XML Content Using Java

Example 3–14 shows how to load XML content into Oracle XML DB by first creating an XMLType instance in Java, given a Document Object Model (DOM).

Example 3–14 Inserting Content into an XMLType Table Using Java

```
public void doInsert(Connection conn, Document doc)
throws Exception
{
   String SQLTEXT = "INSERT INTO purchaseorder VALUES (?)";
   XMLType xml = null;
   xml = XMLType.createXML(conn,doc);
   OraclePreparedStatement sqlStatement = null;
   sqlStatement = (OraclePreparedStatement) conn.prepareStatement(SQLTEXT);
   sqlStatement.setObject(1,xml);
   sqlStatement.execute();
}
```

A simple bulk loader application is available on the Oracle Technology Network (OTN) site at http://www.oracle.com/technetwork/database-features/xmldb/overview/index.html. It shows how to load a directory of XML files into Oracle XML DB using Java Database Connectivity (JDBC). JDBC is a set of Java interfaces to Oracle Database.

Loading XML Content Using C

Example 3–15 shows how to insert XML content into an XMLType table using C code, by creating an XMLType instance given a DOM. See "Loading XML Data Using C (OCI)" on page A-47 for a complete listing of this example.

Example 3–15 Inserting Content into an XMLType Table Using C

```
. . .
void main()
{
  OCIType *xmltdo;
  xmldocnode  *doc;
  ocixmldbparam params[1];
  xmlerr       err;
  xmlctx  *xctx;
  oratext *ins_stmt;
  sword    status;
  xmlnode *root;
  oratext buf[10000];

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_connect();

  /* Get an XML context */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &dur;
  xctx = OCIXmlDbInitXmlCtx(envhp, svchp, errhp, params, 1);
  if (!(doc = XmlLoadDom(xctx, &err, "file", filename,
                         "schema_location", schemaloc, NULL)))
    {
      printf("Parse failed.\n");
      return;
```

```
    }
  else
    printf("Parse succeeded.\n");
  root = XmlDomGetDocElem(xctx, doc);
  printf("The xml document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "buffer", buf, "buffer_length", 10000, NULL);
  printf("%s\n", buf);

  /* Insert the document into my_table */
  ins_stmt = (oratext *)"insert into purchaseorder values (:1)";
  status = OCITypeByName(envhp, errhp, svchp, (const text *) "SYS",
                         (ub4) strlen((const char *)"SYS"), (const text *) "XMLTYPE",
                         (ub4) strlen((const char *)"XMLTYPE"), (CONST text *) 0,
                         (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                         (OCIType **) &xmltdo);
  if (status == OCI_SUCCESS)
    {
      status = exec_bind_xml(svchp, errhp, stmthp, (void *)doc,
                             xmltdo, ins_stmt);
    }
  if (status == OCI_SUCCESS)
    printf ("Insert successful\n");
  else
    printf ("Insert failed\n");

  /* Free XML instances */
  if (doc)
    XmlFreeDocument((xmlctx *)xctx, (xmldocnode *)doc);
  /* Free XML CTX */
  OCIXmlDbFreeXmlCtx(xctx);
  free_oci();
}
```

Note: For simplicity in demonstrating this feature, this example does not perform the password management techniques that a deployed system normally uses. In a production environment, follow the Oracle Database password management guidelines, and disable any sample accounts. See *Oracle Database Security Guide* for password management guidelines and other security recommendations.

Loading Large XML Files that Contain Small XML Documents

When loading large XML files consisting of a collection of smaller XML documents, it is often more efficient to use Simple API for XML (SAX) parsing to break the file into a set of smaller documents, and then insert those documents. SAX is an XML standard interface provided by XML parsers for event-based applications.

You can use SAX to load a database table from very large XML files in the order of 30 MB or larger, by creating individual documents from a collection of nodes. You can also bulk load XML files.

See Also:

- http://www.saxproject.org/ for information about SAX
- http://www.oracle.com/technetwork/database-features/xmldb/overview/index.html, for an application example that loads large files using SAX

Loading Large XML Files Using SQL*Loader

Use SQL*Loader to load large amounts of XML data into Oracle Database. SQL*Loader loads in one of two modes, conventional or direct path. Table 3–1 compares these modes.

Table 3–1 SQL*Loader – Conventional and Direct-Path Load Modes

Conventional Load Mode	Direct-Path Load Mode
Uses SQL to load data into Oracle Database. This is the *default* mode.	Bypasses SQL and streams the data directly into Oracle Database.
Advantage: Follows SQL semantics. For example triggers are fired and constraints are checked.	*Advantage:* This loads data much faster than the conventional load mode.
Disadvantage: This loads data slower than with the direct load mode.	*Disadvantage:* SQL semantics is not obeyed. For example triggers are not fired and constraints are not checked.

When loading LOBs with SQL*Loader direct-path load, much memory can be used. If the message `SQL*Loader 700 (out of memory)` appears, then it is likely that more rows are being included in each load call than can be handled by your operating system and process memory. *Workaround:* use the `ROWS` option to read a smaller number of rows in each data save.

See Also: Chapter 36, "How to Load XML Data"

Loading XML Documents into the Repository Using DBMS_XDB_REPOS

You can also store XML documents in Oracle XML DB Repository, and access these documents using path-based rather than table-based techniques. To load an XML document into the repository under a given path, use PL/SQL function `DBMS_XDB_REPOS.createResource`. Example 3–16 illustrates this.

Example 3–16 Inserting XML Content into the Repository Using CREATERESOURCE

```
DECLARE
  res BOOLEAN;
BEGIN
  res := DBMS_XDB_REPOS.createResource('/home/QUINE/purchaseOrder.xml',
                                       bfilename('XMLDIR', 'purchaseOrder.xml'),
                                       nls_charset_id('AL32UTF8'));
END;
/
```

Many operations for configuring and using Oracle XML DB are based on processing one or more XML documents. Examples include registering an XML schema and performing an XSL transformation. The easiest way to make these XML documents available to Oracle Database is to load them into Oracle XML DB Repository.

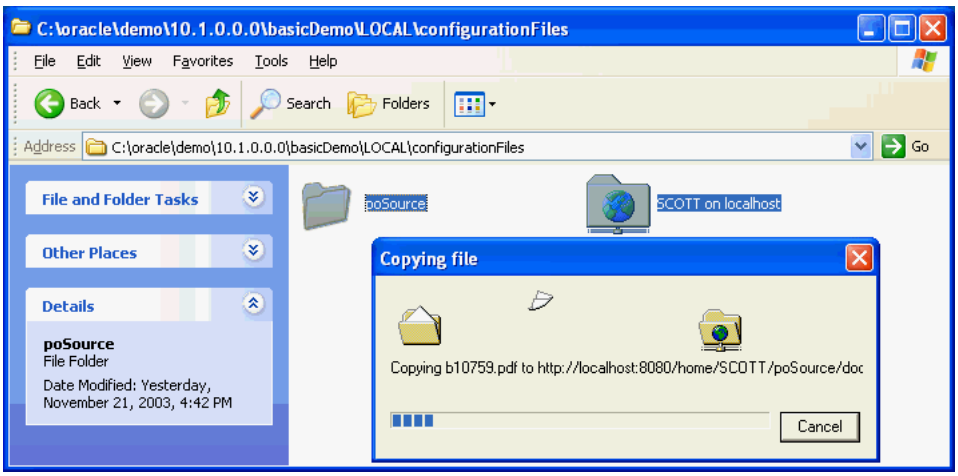
Loading Documents into the Repository Using Protocols

Oracle XML DB Repository can store XML documents that are either XML schema-based or non-schema-based. It can also store content that is not XML data, such as HTML files, image files, and Microsoft Word documents.

You can load XML documents from a local file system into Oracle XML DB Repository using protocols such as WebDAV, from Windows Explorer or other tools that support

WebDAV. Figure 3–1 shows a simple drag and drop operation for copying the contents of the SCOTT folder from the local hard drive to folder poSource in the Oracle XML DB Repository.

Figure 3–1 Loading Content into the Repository Using Windows Explorer



The copied folder might contain, for example, an XML schema document, an HTML page, and some XSLT stylesheets.

Querying XML Content Stored in Oracle XML DB

This section describes techniques for querying Oracle XML DB and retrieving XML content. It contains these topics:

- PurchaseOrder XML Document
- Retrieving the Content of an XML Document Using Pseudocolumn OBJECT_VALUE
- Accessing Fragments or Nodes of an XML Document Using XMLQUERY
- Accessing Text Nodes and Attribute Values Using XMLCAST and XMLQUERY
- Searching an XML Document Using XMLEXISTS, XMLCast, and XMLQuery
- Performing SQL Operations on XMLType Fragments Using XMLTABLE

> **Note:** For efficient query performance you typically need to create indexes. For information about indexing XML data, see Chapter 6, "Indexes for XMLType Data".

PurchaseOrder XML Document

Examples in this section are based on the PurchaseOrder XML document shown in Example 3–17.

Example 3–17 PurchaseOrder XML Instance Document

```
<PurchaseOrder
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:noNamespaceSchemaLocation=
```

```
    "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
  <Reference>SBELL-20021009123336O1PDT</Reference>
  <Actions>
    <Action>
      <User>SVOLLMAN</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Sarah J. Bell</Requestor>
  <User>SBELL</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Sarah J. Bell</name>
    <address>400 Oracle Parkway
      Redwood Shores
      CA
      94065
      USA</address>
    <telephone>650 506 7400</telephone>
  </ShippingInstructions>
  <SpecialInstructions>Air Mail</SpecialInstructions>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>A Night to Remember</Description>
      <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="2">
      <Description>The Unbearable Lightness Of Being</Description>
      <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="3">
      <Description>Sisters</Description>
      <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
    </LineItem>
  </LineItems>
</PurchaseOrder>
```

Retrieving the Content of an XML Document Using Pseudocolumn OBJECT_VALUE

Pseudocolumn `OBJECT_VALUE` can be used as an alias for the value of an object table. For an `XMLType` table that consists of a single column of `XMLType`, the entire XML document is retrieved. (`OBJECT_VALUE` replaces the `value(x)` and `SYS_NC_ROWINFO$` aliases used in releases prior to Oracle Database10g Release 1.)

In Example 3–18, the SQL*Plus settings `PAGESIZE` and `LONG` are used to ensure that the entire document is printed correctly, without line breaks. (The output has been formatted for readability.)

Example 3–18 Retrieving an Entire XML Document Using OBJECT_VALUE

```
SET LONG 10000
SET PAGESIZE 100

SELECT OBJECT_VALUE FROM purchaseorder;

OBJECT_VALUE
--------------------------------------------------------------------------
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:noNamespaceSchemaLocation="http://localhost:8080/source/schemas
/poSource/xsd/purchaseOrder.xsd">
```

```
  <Reference>SBELL-20021009123336O1PDT</Reference>
  <Actions>
    <Action>
      <User>SVOLLMAN</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Sarah J. Bell</Requestor>
  <User>SBELL</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Sarah J. Bell</name>
    <address>400 Oracle Parkway
Redwood Shores
CA
94065
USA</address>
    <telephone>650 506 7400</telephone>
  </ShippingInstructions>
  <SpecialInstructions>Air Mail</SpecialInstructions>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>A Night to Remember</Description>
      <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="2">
      <Description>The Unbearable Lightness Of Being</Description>
      <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="3">
      <Description>Sisters</Description>
      <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
    </LineItem>
  </LineItems>
</PurchaseOrder>

1 row selected.
```

Accessing Fragments or Nodes of an XML Document Using XMLQUERY

You can use SQL/XML function `XMLQuery` to extract the nodes that match an XPath expression. The result is returned as an instance of `XMLType`. Example 3–19 illustrates this with several queries.

Example 3–19 Accessing XML Fragments Using XMLQUERY

The following query returns an `XMLType` instance containing the `Reference` element that matches the XPath expression.

```
SELECT XMLQuery('/PurchaseOrder/Reference' PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM purchaseorder;

XMLQUERY('/PURCHASEORDER/REFERENCE'PASSINGOBJECT_
------------------------------------------------
<Reference>SBELL-20021009123336O1PDT</Reference>

1 row selected.
```

The following query returns an `XMLType` instance containing the first `LineItem` element in the `LineItems` collection:

```
SELECT XMLQuery('/PurchaseOrder/LineItems/LineItem[1]'
                PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM purchaseorder;

XMLQUERY('/PURCHASEORDER/LINEITEMS/LINEITEM[1]'PASSINGOBJECT_
------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>A Night to Remember</Description>
  <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
</LineItem>

1 row selected.
```

The following query returns an `XMLType` instance that contains the three `Description` elements that match the XPath expression. These elements are returned as nodes in a single `XMLType` instance. The `XMLType` instance does not have a single root node; it is an XML *fragment*.

```
SELECT XMLQuery('/PurchaseOrder/LineItems/LineItem/Description'
                PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM purchaseorder;

XMLQUERY('/PURCHASEORDER/LINEITEMS/LINEITEM/DESCRIPTION'PASSINGOBJECT_
----------------------------------------------------------------------
<Description>A Night to Remember</Description>
<Description>The Unbearable Lightness Of Being</Description>
<Description>Sisters</Description>

1 row selected.
```

See Also: "Performing SQL Operations on XMLType Fragments Using XMLTABLE" on page 3-20

Accessing Text Nodes and Attribute Values Using XMLCAST and XMLQUERY

You can access text node and attribute values using SQL/XML standard functions `XMLQuery` and `XMLCast`. To do this, the XPath expression passed to `XMLQuery` must uniquely identify a *single* text node or attribute value within the document – that is, a *leaf* node. Example 3–20 illustrates this using several queries.

Example 3–20 Accessing a Text Node Value Using XMLCAST and XMLQuery

The following query returns the value of the text node associated with the `Reference` element that matches the target XPath expression. The value is returned as a `VARCHAR2` value.

```
SELECT  XMLCast(XMLQuery('$p/PurchaseOrder/Reference/text()'
                         PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(30))
  FROM purchaseorder;

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
SBELL-20021009123336O1PDT

1 row selected.
```

The following query returns the value of the text node associated with a `Description` element contained in a `LineItem` element. The particular `LineItem` element is specified by its `Id` attribute value. The predicate that identifies the `LineItem` element is

[Part/@Id="715515011020"]. The at-sign character (@) specifies that Id is an attribute rather than an element. The value is returned as a VARCHAR2 value.

```
SELECT XMLCast(
         XMLQuery('$p/PurchaseOrder/LineItems/LineItem[Part/@Id="715515011020"]/Description/text()'
                  PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(30))
  FROM purchaseorder;

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
Sisters

1 row selected.
```

The following query returns the value of the text node associated with the Description element contained in the first LineItem element. The first LineItem element is indicated by the position predicate [1].

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/LineItems/LineItem[1]/Description'
                        PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(4000))
  FROM purchaseorder;

XMLCAST(XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[1]/DESCRIPTION'PASSINGOBJECT_VALUEAS"P"
--------------------------------------------------------------------------------------------
A Night to Remember

1 row selected.
```

See Also: Chapter 4, "XQuery and Oracle XML DB" for information on SQL/XML functions XMLQuery and XMLCast

Searching an XML Document Using XMLEXISTS, XMLCast, and XMLQuery

SQL/XML standard function XMLExists evaluates whether or not a given document contains a node that matches a W3C XPath expression. Function XMLExists returns a Boolean value of true if the document contains the node specified by the XPath expression supplied to the function and a value of false if it does not. Since XPath expressions can contain predicates, XMLExists can determine whether or not a given node exists in the document, and whether or not a node with the specified value exists in the document.

Similarly, you can use SQL/XML functions XMLCast and XMLQuery in a SQL WHERE clause to limit the query results to documents that satisfy some property. Example 3–21 illustrates the use of XMLExists, XMLCast, and XMLQuery to search for documents.

Example 3–21 Searching XML Content Using XMLExists, XMLCast, and XMLQuery

The following query uses XMLExists to check if the XML document contains an element named Reference that is a child of the root element PurchaseOrder:

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
       132
```

```
1 row selected.
```

The following query checks if the value of the text node associated with the `Reference` element is `SBELL-2002100912333601PDT`:

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
         1
1 row selected.
```

This query checks whether the XML document contains a root element `PurchaseOrder` that contains a `LineItems` element that contains a `LineItem` element that contains a `Part` element with an `Id` attribute.

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/LineItems/LineItem/Part/@Id'
                  PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
       132

1 row selected.
```

The following query checks whether the XML document contains a root element `PurchaseOrder` that contains a `LineItems` element that contains a `LineItem` element that contains a `Part` element with `Id` attribute value `715515009058`.

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]'
                  PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
        21
```

The following query checks whether the XML document contains a root element `PurchaseOrder` that contains a `LineItems` element whose *third* `LineItem` element contains a `Part` element with `Id` attribute value `715515009058`.

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists(
          '$p/PurchaseOrder/LineItems/LineItem[3]/Part[@Id="715515009058"]'
          PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
         1
1 row selected.
```

The following query limits the results of the `SELECT` statement to rows where the text node associated with element `User` starts with the letter `S`. XQuery does not include support for `LIKE`-based queries.

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p"
                        RETURNING CONTENT)
               AS VARCHAR2(30))
```

```
  FROM purchaseorder
  WHERE XMLCast(XMLQuery('$p/PurchaseOrder/User' PASSING OBJECT_VALUE AS "p"
                         RETURNING CONTENT)
                AS VARCHAR2(30))
        LIKE 'S%';

XMLCAST(XMLQUERY('$P/PURCHASEORDER
--------------------------------
SBELL-20021009123336231PDT
SBELL-20021009123336331PDT
SKING-20021009123336321PDT
...
36 rows selected.
```

The following query uses `XMLExists` to limit the results of a `SELECT` statement to rows where the text node of element `User` contains the value `SBELL`.

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p"
                        RETURNING CONTENT)
               AS VARCHAR2(30)) "Reference"
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[User="SBELL"]' PASSING OBJECT_VALUE AS "p");

Reference
------------------------------
SBELL-20021009123336231PDT
SBELL-20021009123336331PDT
SBELL-20021009123337353PDT
SBELL-20021009123338304PDT
SBELL-20021009123338505PDT
SBELL-20021009123335771PDT
SBELL-20021009123335280PDT
SBELL-20021009123333763PDT
SBELL-20021009123333601PDT
SBELL-20021009123336362PDT
SBELL-20021009123336532PDT
SBELL-20021009123338204PDT
SBELL-20021009123337673PDT

13 rows selected.
```

The following query uses SQL/XML functions `XMLQuery` and `XMLExists` to find the `Reference` element for any `PurchaseOrder` element whose first `LineItem` element contains an order for the item with `Id` `715515009058`. Function `XMLExists` is used in the `WHERE` clause to determine which rows are selected, and `XMLQuery` is used in the `SELECT` list to control which part of the selected documents appears in the result.

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p"
                        RETURNING CONTENT)
               AS VARCHAR2(30)) "Reference"
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/LineItems/LineItem[1]/Part[@Id="715515009058"]'
                  PASSING OBJECT_VALUE AS "p");

Reference
-------------------------
SBELL-20021009123336601PDT

1 row selected.
```

Example 3–22 performs a join based on the values of a node in an XML document and data in another, relational table.

Example 3–22 Joining Data from an XMLType Table and a Relational Table

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p"
                        RETURNING CONTENT)
               AS VARCHAR2(30))
  FROM purchaseorder p, hr.employees e
  WHERE XMLCast(XMLQuery('$p/PurchaseOrder/User' PASSING OBJECT_VALUE AS "p"
                         RETURNING CONTENT)
                AS VARCHAR2(30)) = e.email
    AND e.employee_id = 100;

XMLCAST(XMLQUERY('$P/PURCHASEOREDER
----------------------------------
SKING-20021009123336321PDT
SKING-20021009123337153PDT
SKING-20021009123335560PDT
SKING-20021009123336952PDT
SKING-20021009123336622PDT
SKING-20021009123336822PDT
SKING-20021009123336131PDT
SKING-20021009123336392PDT
SKING-20021009123337974PDT
SKING-20021009123338294PDT
SKING-20021009123337703PDT
SKING-20021009123337383PDT
SKING-20021009123337503PDT

13 rows selected.
```

> **See Also:** Chapter 4, "XQuery and Oracle XML DB" for information about SQL/XML functions `XMLQuery`, `XMLExists`, and `XMLCast`

Performing SQL Operations on XMLType Fragments Using XMLTABLE

Example 3–19 demonstrates how to extract an `XMLType` instance that contains the node or nodes that match an XPath expression. When the document contains *multiple* nodes that match the supplied XPath expression, such a query returns an XML *fragment* that contains all of the matching nodes. Unlike an XML document, an XML **fragment** has no single element that is the *root* element.

This kind of result is common in these cases:

- When you retrieve the set of elements contained in a *collection*, in which case all nodes in the fragment are of the same type – see Example 3–23
- When the target XPath expression ends in a *wildcard*, in which case the nodes in the fragment can be of different types – see Example 3–25

You can use SQL/XML function `XMLTable` to break up an XML fragment contained in an `XMLType` instance, inserting the collection-element data into a new, virtual table, which you can then query using SQL—in a join expression, for example. In particular, converting an XML fragment into a virtual table makes it easier to process the result of evaluating an `XMLQuery` expression that returns multiple nodes.

> **See Also:** Chapter 4, "XQuery and Oracle XML DB" for more information about SQL/XML function `XMLTable`

Example 3–23 shows how to access the text nodes for each Description element in the PurchaseOrder document. It breaks up the single XML Fragment output from Example 3–19 into multiple text nodes.

Example 3–23 Accessing Description Nodes Using XMLTABLE

```
SELECT des.COLUMN_VALUE
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem/Description'
                PASSING p.OBJECT_VALUE) des
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

COLUMN_VALUE
------------
<Description>A Night to Remember</Description>
<Description>The Unbearable Lightness Of Being</Description>
<Description>Sisters</Description>

3 rows selected.
```

To use SQL to process the contents of the text nodes, Example 3–23 converts the collection of Description nodes into a *virtual table*, using SQL/XML function XMLTable. The virtual table has three rows, each of which contains a single XMLType instance with a single Description element.

The XPath expression targets the Description elements. The PASSING clause says to use the contents (OBJECT_VALUE) of XMLType table purchaseorder as the context for evaluating the XPath expression.

The XMLTable expression thus *depends* on the purchaseorder table. This is a *left lateral join*. This correlated join ensures a one-to-many (1:N) relationship between the purchaseorder row accessed and the rows generated from it by XMLTable. Because of this correlated join, the purchaseorder table *must appear before* the XMLTable expression in the FROM list. This is a general requirement in any situation where the PASSING clause refers to a column of the table.

Each XMLType instance in the virtual table contains a single Description element. You can use the COLUMNS clause of XMLTable to break up the data targeted by the XPath expression 'Description' into a column named description of SQL data type VARCHAR2(256). The 'Description' expression that defines this column is *relative* to the *context* XPath expression, '/PurchaseOrder/LineItems/LineItem'.

```
SELECT des.description
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE
                COLUMNS description VARCHAR2(256) PATH 'Description') des
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

DESCRIPTION
--------------------------------
A Night to Remember
The Unbearable Lightness Of Being
Sisters

3 rows selected.
```

The COLUMNS clause lets you specify precise SQL data types, which can make static type-checking more helpful. This example uses only a single column (description). To

expose data that is contained at multiple levels in an XMLType table as individual rows in a relational view, apply XMLTable to each document level to be broken up and stored in relational columns. See Example 9–2 on page 9-3 for an example.

Example 3–24 counts the number of elements in a collection. It also shows how SQL keywords such as ORDER BY and GROUP BY can be applied to the virtual table data created by SQL/XML function XMLTable.

Example 3–24 Counting the Number of Elements in a Collection Using XMLTABLE

```
SELECT reference, count(*)
  FROM purchaseorder,
       XMLTable('/PurchaseOrder' PASSING OBJECT_VALUE
                COLUMNS reference VARCHAR2(32) PATH 'Reference',
                        lineitem  XMLType      PATH 'LineItems/LineItem'),
       XMLTable('LineItem' PASSING lineitem)
  WHERE XMLExists('$p/PurchaseOrder[User="SBELL"]'
                  PASSING OBJECT_VALUE AS "p")
  GROUP BY reference
  ORDER BY reference;

REFERENCE                    COUNT(*)
--------------------------   --------
SBELL-20021009123335280PDT         20
SBELL-20021009123335771PDT         21
SBELL-2002100912333601PDT           3
SBELL-20021009123336231PDT         25
SBELL-20021009123336331PDT         10
SBELL-20021009123336362PDT         15
SBELL-20021009123336532PDT         14
SBELL-20021009123337353PDT         10
SBELL-2002100912333763PDT          21
SBELL-20021009123337673PDT         10
SBELL-20021009123338204PDT         14
SBELL-20021009123338304PDT         24
SBELL-20021009123338505PDT         20

13 rows selected.
```

The query in Example 3–24 locates the set of XML documents that match the XPath expression to SQL/XML function XMLExists. It generates a virtual table with two columns:

- reference, containing the Reference node for each document selected
- lineitem, containing the set of LineItem nodes for each document selected

It counts the number of LineItem nodes for each document. A correlated join ensures that the GROUP BY correctly determines which LineItem elements belong to which PurchaseOrder element.

Example 3–25 shows how to use SQL/XML function XMLTable to count the number of *child* elements of a given element. The XPath expression passed to XMLTable contains a wildcard (*) that matches all elements that are direct descendants of a PurchaseOrder element. Each row of the virtual table created by XMLTable contains a node that matches the XPath expression. Counting the number of rows in the virtual table provides the number of element children of element PurchaseOrder.

Example 3–25 Counting the Number of Child Elements in an Element Using XMLTABLE

```
SELECT count(*)
```

```
  FROM purchaseorder p, XMLTable('/PurchaseOrder/*' PASSING p.OBJECT_VALUE)
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
         9

1 row selected.
```

Updating XML Content Stored in Oracle XML DB

You can update XML content replacing either the entire contents of a document or parts of a document. The ability to perform partial updates on XML documents is very powerful, particularly when you make small changes to large documents, as it can significantly reduce the amount of network traffic and disk input-output required to perform the update.

You can make multiple changes to a document in a single operation. Each change uses an XQuery expression to identify a node to be updated, and specifies the new value for that node.

Example 3–26 updates the text node associated with element `User`.

Example 3–26 Updating a Text Node

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/User' PASSING OBJECT_VALUE AS "p"
                                                RETURNING CONTENT)
               AS VARCHAR2(60))
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLCAST(XMLQUERY('$P/PURCHAS
----------------------------
SBELL

1 row selected.

UPDATE purchaseorder
SET OBJECT_VALUE =
    XMLQuery('copy $i := $p1 modify
                (for $j in $i/PurchaseOrder/User
                 return replace value of node $j with $p2)
              return $i'
             PASSING OBJECT_VALUE AS "p1", 'SKING' AS "p2" RETURNING CONTENT)
    WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                    PASSING OBJECT_VALUE AS "p");

1 row updated.

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/User' PASSING OBJECT_VALUE AS "p"
                                                RETURNING CONTENT)
               AS VARCHAR2(60))
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLCAST(XMLQUERY('$P/PURCHAS
----------------------------
```

```
SKING

1 row selected.
```

Example 3–27 replaces an entire element within an XML document. The XQuery expression references the element, and the replacement value is passed as an `XMLType` object.

Example 3–27 Replacing an Entire Element Using XQuery Update

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[1]'
               PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHAS
--------------------
<LineItem ItemNumber="1">
  <Description>A Night to Remember</Description>
  <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
</LineItem>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
        XMLQuery('copy $i := $p1 modify
                    (for $j in $i/PurchaseOrder/LineItems/LineItem[1]
                     return replace node $j with $p2)
                  return $i'
                 PASSING OBJECT_VALUE AS "p1",
                         XMLType('<LineItem ItemNumber="1">
                                    <Description>The Lady Vanishes</Description>
                                    <Part Id="37429122129" UnitPrice="39.95"
                                          Quantity="1"/>
                                  </LineItem>') AS "p2"
                 RETURNING CONTENT)
        WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                        PASSING OBJECT_VALUE AS "p");

1 row updated.

SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[1]'
               PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHAS
--------------------
<LineItem ItemNumber="1">
  <Description>The Lady Vanishes</Description>
  <Part Id="37429122129" UnitPrice="39.95" Quantity="1"/>
</LineItem>

1 row selected.
```

You can make multiple changes to a document in one statement. Example 3–28 changes the values of text nodes belonging to elements `CostCenter` and `SpecialInstructions` in a single SQL `UPDATE` statement.

Example 3–28 Changing Text Node Values Using XQuery Update

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/CostCenter'
                        PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(4)) "Cost Center",
       XMLCast(XMLQuery('$p/PurchaseOrder/SpecialInstructions'
                        PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(2048)) "Instructions"
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

Cost Center  Instructions
------------ ------------
S30          Air Mail

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
        XMLQuery('copy $i := $p1 modify
                    ((for $j in $i/PurchaseOrder/CostCenter
                      return replace value of node $j with $p2)
                     (for $j in $i/PurchaseOrder/SpecialInstructions
                      return replace value of node $j with $p3))
                  return $i'
                  PASSING OBJECT_VALUE AS "p1",
                          'B40' AS "p2",
                          'Priority Overnight Service' AS "p3"
                  RETURNING CONTENT)
        WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                        PASSING OBJECT_VALUE AS "p");

1 row updated.

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/CostCenter'
                        PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(4)) "Cost Center",
       XMLCast(XMLQuery('$p/PurchaseOrder/SpecialInstructions'
                        PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(2048)) "Instructions"
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

Cost Center  Instructions
------------ --------------------------
B40          Priority Overnight Service

1 row selected.
```

Generating XML Data from Relational Data

This section presents examples of using Oracle XML DB to generate XML data from relational data.

See Also:

- Chapter 4, "XQuery and Oracle XML DB"
- Chapter 8, "Generation of XML Data from Relational Data"

Generating XML Data from Relational Data Using SQL/XML Functions

You can use standard SQL/XML functions to generate one or more XML documents. SQL/XML function `XMLQuery` is the most general way to do this. Other SQL/XML functions that you can use for this are the following:

- `XMLElement` creates a element
- `XMLAttributes` adds attributes to an element
- `XMLForest` creates forest of elements
- `XMLAgg` creates a single element from a collection of elements

The query in Example 3–29 uses these functions to generate an XML document that contains information from the tables `departments`, `locations`, `countries`, `employees`, and `jobs`.

Example 3–29 Generating XML Data Using SQL/XML Functions

```
SELECT XMLElement(
         "Department",
         XMLAttributes(d.Department_id AS "DepartmentId"),
         XMLForest(d.department_name AS "Name"),
         XMLElement(
           "Location",
           XMLForest(street_address AS "Address",
                     city AS "City",
                     state_province AS "State",
                     postal_code AS "Zip",
                     country_name AS "Country")),
           XMLElement(
             "EmployeeList",
             (SELECT XMLAgg(
                       XMLElement(
                         "Employee",
                         XMLAttributes(e.employee_id AS "employeeNumber"),
                         XMLForest(
                           e.first_name AS "FirstName",
                           e.last_name AS "LastName",
                           e.email AS "EmailAddress",
                           e.phone_number AS "PHONE_NUMBER",
                           e.hire_date AS "StartDate",
                           j.job_title AS "JobTitle",
                           e.salary AS "Salary",
                           m.first_name || ' ' || m.last_name AS "Manager"),
                         XMLElement("Commission", e.commission_pct)))
                FROM hr.employees e, hr.employees m, hr.jobs j
                WHERE e.department_id = d.department_id
                  AND j.job_id = e.job_id
                  AND m.employee_id = e.manager_id)))
  AS XML
  FROM hr.departments d, hr.countries c, hr.locations l
  WHERE department_name = 'Executive'
    AND d.location_id = l.location_id
    AND l.country_id  = c.country_id;
```

The query returns the following XML:

```
XML
--------------------------------------------------------------------------------
<Department DepartmentId="90"><Name>Executive</Name><Location><Address>2004
 Charade Rd</Address><City>Seattle</City><State>Washingto
n</State><Zip>98199</Zip><Country>United States of
 America</Country></Location><EmployeeList><Employee
 employeeNumber="101"><FirstNa
me>Neena</FirstName><LastName>Kochhar</LastName><EmailAddress>NKOCHHAR</EmailAdd
ess><PHONE_NUMBER>515.123.4568</PHONE_NUMBER><Start
Date>2005-09-21</StartDate><JobTitle>Administration Vice
 President</JobTitle><Salary>17000</Salary><Manager>Steven King</Manager><Com
mission></Commission></Employee><Employee
 employeeNumber="102"><FirstName>Lex</FirstName><LastName>De
 Haan</LastName><EmailAddress>L
DEHAAN</EmailAddress><PHONE_NUMBER>515.123.4569</PHONE
NUMBER><StartDate>2001-01-13</StartDate><JobTitle>Administration Vice Presiden
t</JobTitle><Salary>17000</Salary><Manager>Steven
 King</Manager><Commission></Commission></Employee></EmployeeList></Department>
```

This query generates element `Department` for each row in the `departments` table.

- Each `Department` element contains attribute `DepartmentID`. The value of `DepartmentID` comes from the `department_id` column. The `Department` element contains sub-elements `Name`, `Location`, and `EmployeeList`.
- The text node associated with the `Name` element comes from the `name` column in the `departments` table.
- The `Location` element has child elements `Address`, `City`, `State`, `Zip`, and `Country`. These elements are constructed by creating a forest of named elements from columns in the `locations` and `countries` tables. The values in the columns become the text node for the named element.
- The `EmployeeList` element contains an aggregation of `Employee` Elements. The content of the `EmployeeList` element is created by a subquery that returns the set of rows in the `employees` table that correspond to the current department. Each `Employee` element contains information about the employee. The contents of the elements and attributes for each `Employee` element is taken from tables `employees` and `jobs`.

The output generated by SQL/XML functions is generally *not* pretty-printed. The only exception is function `XMLSerialize`—use `XMLSerialize` to pretty-print. This lets the other SQL/XML functions (1) avoid creating a full DOM when generating the required output, and (2) reduce the size of the generated document. This lack of pretty-printing by most SQL/XML functions does not matter to most applications. However, it makes verifying the generated output manually more difficult.

You can also create and query an `XMLType` view that is built using the SQL/XML generation functions. Example 3–30 and Example 3–31 illustrate this. Such an `XMLType` view has the effect of persisting relational data as XML content. Rows in `XMLType` views can also be persisted as documents in Oracle XML DB Repository.

Example 3–30 Creating XMLType Views Over Conventional Relational Tables

```
CREATE OR REPLACE VIEW department_xml OF XMLType
  WITH OBJECT ID (substr(
                    XMLCast(
                      XMLQuery('$p/Department/Name'
```

```
                                PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                      AS VARCHAR2(30)),
                    1,
                    128))
  AS
  SELECT XMLElement(
           "Department",
           XMLAttributes(d.department_id AS "DepartmentId"),
           XMLForest(d.department_name AS "Name"),
           XMLElement("Location", XMLForest(street_address AS "Address",
                                            city AS "City",
                                            state_province AS "State",
                                            postal_code AS "Zip",
                                            country_name AS "Country")),
           XMLElement(
             "EmployeeList",
             (SELECT XMLAgg(
                       XMLElement(
                          "Employee",
                          XMLAttributes(e.employee_id AS "employeeNumber"),
                          XMLForest(e.first_name AS "FirstName",
                                    e.last_name AS "LastName",
                                    e.email AS "EmailAddress",
                                    e.phone_number AS "PHONE_NUMBER",
                                    e.hire_date AS "StartDate",
                                    j.job_title AS "JobTitle",
                                    e.salary AS "Salary",
                                    m.first_name || ' ' ||
                                    m.last_name AS "Manager"),
                          XMLElement("Commission", e.commission_pct)))
                FROM hr.employees e, hr.employees m, hr.jobs j
                WHERE e.department_id = d.department_id
                  AND j.job_id = e.job_id
                  AND m.employee_id = e.manager_id))).extract('/*')
    AS XML
    FROM hr.departments d, hr.countries c, hr.locations l
    WHERE d.location_id = l.location_id
      AND l.country_id  = c.country_id;
```

In Example 3–31, the XPath expression passed to SQL/XML function `XMLExists` restricts the query result set to the node that contains the `Executive` department information. The result is shown pretty-printed here for clarity.

Example 3–31 Querying XMLType Views

```
SELECT OBJECT_VALUE FROM department_xml
  WHERE XMLExists('$p/Department[Name="Executive"]' PASSING OBJECT_VALUE AS "p");

OBJECT_VALUE
------------------------------------------------
<Department DepartmentId="90">
  <Name>Executive</Name>
  <Location>
    <Address>2004 Charade Rd</Address>
    <City>Seattle</City>
    <State>Washington</State>
    <Zip>98199</Zip>
    <Country>United States of America</Country>
  </Location>
  <EmployeeList>
```

```
      <Employee employeeNumber="101">
        <FirstName>Neena</FirstName>
        <LastName>Kochhar</LastName>
        <EmailAddress>NKOCHHAR</EmailAddress>
        <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
        <StartDate>2005-09-21</StartDate>
        <JobTitle>Administration Vice President</JobTitle>
        <Salary>17000</Salary>
        <Manager>Steven King</Manager>
        <Commission/>
      </Employee>
      <Employee employeeNumber="102">
        <FirstName>Lex</FirstName>
        <LastName>De Haan</LastName>
        <EmailAddress>LDEHAAN</EmailAddress>
        <PHONE_NUMBER>515.123.4569</PHONE_NUMBER>
        <StartDate>2001-01-13</StartDate>
        <JobTitle>Administration Vice President</JobTitle>
        <Salary>17000</Salary>
        <Manager>Steven King</Manager>
        <Commission/>
      </Employee>
    </EmployeeList>
  </Department>

  1 row selected.
```

As can be seen from the following execution plan output, Oracle XML DB is able to correctly rewrite the XPath-expression argument in the `XMLExists` expression into a `SELECT` statement on the underlying relational tables.

```
SELECT OBJECT_VALUE FROM department_xml
  WHERE XMLExists('$p/Department[Name="Executive"]' PASSING OBJECT_VALUE AS "p");

PLAN_TABLE_OUTPUT
-----------------------------------------------------------------------------------------------------------
Plan hash value: 2414180351

-----------------------------------------------------------------------------------------------------------
| Id  | Operation                            | Name              | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                     |                   |     1 |    80 |     3   (0)| 00:00:01 |
|   1 |  SORT AGGREGATE                      |                   |     1 |   115 |            |          |
|*  2 |   HASH JOIN                          |                   |    10 |  1150 |     7  (15)| 00:00:01 |
|*  3 |    HASH JOIN                         |                   |    10 |   960 |     5  (20)| 00:00:01 |
|   4 |     TABLE ACCESS BY INDEX ROWID BATCHED| EMPLOYEES         |    10 |   690 |     2   (0)| 00:00:01 |
|*  5 |      INDEX RANGE SCAN                | EMP_DEPARTMENT_IX |    10 |       |     1   (0)| 00:00:01 |
|   6 |     TABLE ACCESS FULL                | JOBS              |    19 |   513 |     2   (0)| 00:00:01 |
|   7 |    TABLE ACCESS FULL                 | EMPLOYEES         |   107 |  2033 |     2   (0)| 00:00:01 |
|   8 |  NESTED LOOPS                        |                   |     1 |    80 |     3   (0)| 00:00:01 |
|   9 |   NESTED LOOPS                       |                   |     1 |    68 |     3   (0)| 00:00:01 |
|* 10 |    TABLE ACCESS FULL                 | DEPARTMENTS       |     1 |    19 |     2   (0)| 00:00:01 |
|  11 |    TABLE ACCESS BY INDEX ROWID       | LOCATIONS         |     1 |    49 |     1   (0)| 00:00:01 |
|* 12 |     INDEX UNIQUE SCAN                | LOC_ID_PK         |     1 |       |     0   (0)| 00:00:01 |
|* 13 |   INDEX UNIQUE SCAN                  | COUNTRY_C_ID_PK   |     1 |    12 |     0   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - access("M"."EMPLOYEE_ID"="E"."MANAGER_ID")
   3 - access("J"."JOB_ID"="E"."JOB_ID")
   5 - access("E"."DEPARTMENT_ID"=:B1)
```

```
  10 - filter("D"."DEPARTMENT_NAME"='Executive')
  12 - access("D"."LOCATION_ID"="L"."LOCATION_ID")
  13 - access("L"."COUNTRY_ID"="C"."COUNTRY_ID")

30 rows selected.
```

Note: XPath rewrite on XML expressions that operate on `XMLType` views is only supported when nodes referenced in the XPath expression are *not* descendants of an element created using SQL function `XMLAgg`.

Generating XML Data from Relational Data Using DBURITYPE

You can also generate XML from relational data using SQL function `DBURIType`. Function `DBURIType` exposes one or more rows in a given table or view as a single XML document. The name of the root element is derived from the name of the table or view. The root element contains a set of `ROW` elements. There is one `ROW` element for each row in the table or view. The children of each `ROW` element are derived from the columns in the table or view. Each child element contains a text node with the value of the column for the given row.

Example 3–32 shows how to use SQL function `DBURIType` to access the contents of table `departments` in database schema `HR`. It uses method `getXML()` to return the resulting document as an `XMLType` instance.

Example 3–32 Generating XML Data from a Relational Table Using DBURIType and getXML()

```
SELECT DBURIType('/HR/DEPARTMENTS').getXML() FROM DUAL;

DBURITYPE('/HR/DEPARTMENTS').GETXML()
-----------------------------------------------------
<?xml version="1.0"?>
<DEPARTMENTS>
 <ROW>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
  <DEPARTMENT_NAME>Administration</DEPARTMENT_NAME>
  <MANAGER_ID>200</MANAGER_ID>
  <LOCATION_ID>1700</LOCATION_ID>
 </ROW>
...
 <ROW>
  <DEPARTMENT_ID>20</DEPARTMENT_ID>
  <DEPARTMENT_NAME>Marketing</DEPARTMENT_NAME>
  <MANAGER_ID>201</MANAGER_ID>
  <LOCATION_ID>1800</LOCATION_ID>
 </ROW>
</DEPARTMENTS>
```

Example 3–33 shows how to use an XPath predicate to restrict the rows that are included in an XML document generated using `DBURIType`. The XPath expression in the example restricts the XML document to `DEPARTMENT_ID` columns with value `10`.

Example 3–33 Restricting Rows Using an XPath Predicate

```
SELECT DBURIType('/HR/DEPARTMENTS/ROW[DEPARTMENT_ID="10"]').getXML()
  FROM DUAL;

DBURITYPE('/HR/DEPARTMENTS/ROW[DEPARTMENT_ID="10"]').GETXML()
```

```
--------------------------------------------------------------------
<?xml version="1.0"?>
 <ROW>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
  <DEPARTMENT_NAME>Administration</DEPARTMENT_NAME>
  <MANAGER_ID>200</MANAGER_ID>
  <LOCATION_ID>1700</LOCATION_ID>
 </ROW>

1 row selected.
```

SQL function `DBURIType` provides a simple way to expose some or all rows in a relational table as one or more XML documents. The URL passed to function `DBURIType` can be extended to return a single column from the view or table, but in that case the URL must also include predicates that identify a single row in the target table or view.

Example 3–34 illustrates this. The predicate `[DEPARTMENT_ID="10"]` causes the query to return the value of column `department_name` for the `departments` row where column `department_id` has the value `10`.

Example 3–34 Restricting Rows and Columns Using an XPath Predicate

```
SELECT DBURIType(
         '/HR/DEPARTMENTS/ROW[DEPARTMENT_ID="10"]/DEPARTMENT_NAME').getXML()
  FROM DUAL;

DBURITYPE('/HR/DEPARTMENTS/ROW[DEPARTMENT_ID="10"]/DEPARTMENT_NAME').GETXML()
--------------------------------------------------------------------------------
<?xml version="1.0"?>
 <DEPARTMENT_NAME>Administration</DEPARTMENT_NAME>

1 row selected.
```

SQL function `DBURIType` is less flexible than the SQL/XML functions:

- It provides no way to control the shape of the generated document.
- The data can come only from a single table or view.
- The generated document consists of one or more `ROW` elements. Each `ROW` element contains a child for each column in the target table.
- The names of the child elements are derived from the column names.

To control the names of the XML elements, to include columns from more than one table, or to control which columns from a table appear in the generated document, create a relational view that exposes the desired set of columns as a single row, and then use function `DBURIType` to generate an XML document from the contents of that view.

Character Sets of XML Documents

This section describes how character sets of XML documents are determined.

Caution: *AL32UTF8* is the Oracle Database character set that is appropriate for `XMLType` data. It is equivalent to the IANA registered standard UTF-8 encoding, which supports all valid XML characters.

Do not confuse Oracle Database database character set UTF8 (no hyphen) with database character set AL32UTF8 or with character *encoding* UTF-8. Database character set UTF8 has been *superseded* by AL32UTF8. Do *not* use UTF8 for XML data. Character set UTF8 supports only Unicode version 3.1 and earlier. It does not support all valid XML characters. AL32UTF8 has no such limitation.

Using database character set UTF8 for XML data could potentially *stop a system or affect security negatively*. If a character that is not supported by the database character set appears in an input-document element name, a replacement character (usually "`?`") is substituted for it. This terminates parsing and raises an exception. It can cause an irrecoverable error.

XML Encoding Declaration

Each XML document is composed of units called entities. Each entity in an XML document may use a different encoding for its characters. Entities that are stored in an encoding other than UTF-8 or UTF-16 must begin with an XML declaration containing an encoding specification indicating the character encoding in use. For example:

```
<?xml version='1.0' encoding='EUC-JP' ?>
```

Entities encoded in UTF-16 must begin with the Byte Order Mark (BOM), as described in Appendix F of the XML 1.0 Reference. For example, on big-endian platforms, the BOM required of a UTF-16 data stream is `#xFEFF`.

In the absence of both the encoding declaration and the BOM, the XML entity is assumed to be encoded in UTF-8. Because ASCII is a subset of UTF-8, ASCII entities do not require an encoding declaration.

In many cases, external sources of information are available, besides the XML data, to provide the character encoding in use. For example, the encoding of the data can be obtained from the `charset` parameter of the `Content-Type` field in an HTTP(S) request as follows:

```
Content-Type: text/xml; charset=ISO-8859-4
```

Character-Set Determination When Loading XML Documents into the Database

XML document encoding is detected from the encoding declaration when a document is loaded into the database. However, if the XML data is obtained from a `CLOB` or `VARCHAR` value, then the encoding declaration is *ignored,* because these two data types are always encoded in the database character set.

In addition, when loading data into Oracle XML DB, either through programmatic APIs or transfer protocols, you can provide external encoding to override the document encoding declaration. An error is raised if you try to load a schema-based XML document that contains characters that are not legal in the determined encoding.

The following examples show different ways to specify external encoding:

- Using PL/SQL function `DBMS_XDB_REPOS.createResource` to create a file resource from a `BFILE`, you can specify the file encoding with the *`CSID`* argument. If a zero

CSID is specified then the file encoding is auto-detected from the document encoding declaration.

```
CREATE DIRECTORY xmldir AS '/private/xmldir';
CREATE OR REPLACE PROCEDURE loadXML(filename VARCHAR2, file_csid NUMBER) IS
  xbfile  BFILE;
  RET     BOOLEAN;
BEGIN
  xbfile := bfilename('XMLDIR', filename);
  ret := DBMS_XDB_REPOS.createResource('/public/mypurchaseorder.xml',
                                       xbfile,
                                       file_csid);
END;
/
```

- Use the FTP protocol to load documents into Oracle XML DB. Use the `quote set_charset` FTP command to indicate the encoding of the files to be loaded.

```
ftp> quote set_charset Shift_JIS
ftp> put mypurchaseorder.xml
```

- Use the HTTP(S) protocol to load documents into Oracle XML DB. Specify the encoding of the data to be transmitted to Oracle XML DB in the request header.

```
Content-Type: text/xml; charset= EUC-JP
```

Character-Set Determination When Retrieving XML Documents from the Database

XML documents stored in Oracle XML DB can be retrieved using a SQL client, programmatic APIs, or transfer protocols. You can specify the encoding of the retrieved data.

When XML data is stored as a `CLOB` or `VARCHAR2` value, the encoding declaration, if present, is always ignored for retrieval, just as for storage. The encoding of a retrieved document can thus be different from the encoding explicitly declared in that document.

The character set for an XML document retrieved from the database is determined in the following ways:

- SQL client – If a SQL client (such as SQL*Plus) is used to retrieve XML data, then the character set is determined by the client-side environment variable `NLS_LANG`. In particular, this setting overrides any explicit character-set declarations in the XML data itself.

  For example, if you set the client side `NLS_LANG` variable to `AMERICAN_AMERICA.AL32UTF8` and then retrieve an XML document with encoding `EUC_JP` provided by declaration `<?xml version="1.0" encoding="EUC-JP"?>`, the character set of the retrieved document is `AL32UTF8`, *not* `EUC_JP`.

  > **See Also:** *Oracle Database Globalization Support Guide* for information about `NLS_LANG`

- PL/SQL and APIs – Using PL/SQL or programmatic APIs, you can retrieve XML data into `VARCHAR`, `CLOB`, or `XMLType` data types. As for SQL clients, you can control the encoding of the retrieved data by setting `NLS_LANG`.

  You can also retrieve XML data into a `BLOB` value using `XMLType` and `URIType` methods. These let you specify the character set of the returned `BLOB` value. Here is an example:

```
CREATE OR REPLACE FUNCTION getXML(pathname VARCHAR2, charset VARCHAR2)
  RETURN BLOB IS
  xblob BLOB;
BEGIN
  SELECT XMLSERIALIZE(DOCUMENT e.RES AS BLOB ENCODING charset) INTO xblob
    FROM RESOURCE_VIEW e WHERE equals_path(e.RES, pathname) = 1;
  RETURN xblob;
END;
/
```

- FTP – You can use the FTP `quote set_nls_locale` command to set the character set:

```
ftp> quote set_nls_locale EUC-JP
ftp> get mypurchaseorder.xml
```

See Also: FTP Quote Methods on page 28-12

- HTTP(S) – You can use the `Accept-Charset` parameter in an HTTP(S) request:

```
/httptest/mypurchaseorder.xml  1.1 HTTP/Host: localhost:2345
Accept: text/*
Accept-Charset:  iso-8859-1, utf-8
```

See Also: "Character Sets for HTTP(S)" on page 28-23

Part II

Manipulation of XML Data in Oracle XML DB

Part II of this manual introduces the use of XQuery, XMLType operations, and indexing of XML data. It contains the following chapters:

4

XQuery and Oracle XML DB

This chapter describes how to use the XQuery language with Oracle XML DB. It covers Oracle XML DB support for the language, including the SQL*Plus `XQUERY` command and SQL/XML functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast`.

This chapter contains these topics:

Overview of the XQuery Language

XQuery is the W3C language designed for querying and updating XML data. Oracle XML DB supports the following W3C XQuery standards:

- XQuery 1.0 Recommendation
- XQuery Update Facility 1.0 Recommendation
- XQuery and XPath Full Text 1.0 Recommendation

This section presents an overview of the XQuery language. For more information, consult a recent book on the language or refer to the standards documents that define it, all of which are available at `http://www.w3c.org/`.

XPath Expressions Are XQuery Expressions

The XPath language is a W3C Recommendation for navigating XML documents. It is a subset of the XQuery language: an XPath expression is also an XQuery expression.

XPath models an XML document as a tree of nodes. It provides a set of operations that walk this tree and apply predicates and node-test functions. Applying an XPath expression to an XML document results in a set of nodes. For example, the expression `/PO/PONO` selects all `PONO` child elements under the `PO` root element of a document.

Table 4–1 lists some common constructs used in XPath.

Table 4–1 Common XPath Constructs

XPath Construct	Description
/	Denotes the root of the tree in an XPath expression. For example, `/PO` refers to the child of the root node whose name is `PO`.
/	Used as a path separator to identify the child element nodes of a given element node. For example, `/PurchaseOrder/Reference` identifies `Reference` elements that are children of `PurchaseOrder` elements that are children of the root element.
//	Used to identify all descendants of the current node. For example, `PurchaseOrder//ShippingInstructions` matches any `ShippingInstructions` element under the `PurchaseOrder` element.
*	Used as a wildcard to match any child node. For example, `/PO/*/STREET` matches any street element that is a grandchild of the `PO` element.
[ ]	Used to denote predicate expressions. XPath supports a rich list of binary operators such as `or`, `and`, and `not`. For example, `/PO[PONO = 20 and PNAME = "PO_2"]/SHIPADDR` selects the shipping address element of all purchase orders whose purchase-order number is `20` and whose purchase-order name is `PO_2`. Brackets are also used to denote a position (index). For example, `/PO/PONO[2]` identifies the second purchase-order number element under the `PO` root element.
Functions	XPath and XQuery support a set of built-in functions such as `substring`, `round`, and `not`. In addition, these languages provide for extension functions through the use of namespaces. Oracle XQuery extension functions use the namespace prefix `ora`, for namespace `http://xmlns.oracle.com/xdb`. See "Oracle XQuery Extension Functions" on page 4-19.

An XPath expression must identify a single node or a set of element, text, or attribute nodes. The result of evaluating an XPath expression is never a Boolean expression.

You can select `XMLType` data using PL/SQL, C, or Java. You can also use `XMLType` method `getNumberVal()` to retrieve XML data as a `NUMBER` value.

> **Note:** Oracle SQL functions and `XMLType` methods respect the W3C XPath recommendation, which states that if an XPath expression targets *no nodes* when applied to XML data, then an empty sequence must be returned. An error must *not* be raised in this case.

XQuery: A Functional Language Based on Sequences

XQuery is similar to SQL in many ways, but just as SQL is designed for querying structured, relational data, XQuery is designed especially for querying semi-structured, XML data from a variety of data sources. You can use XQuery to query XML data wherever it is found, whether it is stored in database tables, available through Web Services, or otherwise created on the fly. In addition to querying XML data, XQuery can be used to *construct* XML data. In this regard, XQuery can serve as an alternative or a complement to both XSLT and the other SQL/XML publishing functions, such as `XMLElement`.

XQuery builds on the Post-Schema-Validation Infoset (PSVI) data model, which unites the XML Information Set (Infoset) data model and the XML Schema type system. XQuery defines a new data model, the **XQuery Data Model** (XDM), which is based on *sequences*. Another name for an XQuery sequence is an **XDM instance**.

XQuery Is About Sequences

XQuery is all about manipulating sequences. This makes XQuery similar to a set-manipulation language, except that sequences are ordered and can contain duplicate items. XQuery sequences differ from the sequences in some other languages in that nested XQuery sequences are always *flattened* in their effect.

In many cases, sequences can be treated as unordered, to maximize optimization – where this is available, it is under your control. This **unordered mode** can be applied to join order in the treatment of nested iterations (`for`), and it can be applied to the treatment of XPath expressions (for example, in `/a/b`, the matching `b` elements can be processed without regard to document order).

An XQuery **sequence** consists of zero or more **items**, which can be either *atomic* (scalar) values or XML *nodes*. Items are typed using a rich type system that is based upon the types of XML Schema. This type system is a major change from that of XPath 1.0, which is limited to simple scalar types such as Boolean, number, and string.

XQuery Is Referentially Transparent

XQuery is a *functional* language. As such, it consists of a set of possible *expressions* that are *evaluated* and whose evaluation returns *values* (results). The result of evaluating an XQuery expression has two parts, at least one of which is empty: (a) a sequence (an XDM instance) and (b) a **pending update list**. Informally, the sequence is sometimes spoken of as the expression value, especially when the pending update list is empty, meaning that no data updates are involved.

As a functional language, XQuery is also **referentially transparent**. This means that the *same expression* evaluated in the *same context* returns the *same value*.

Exceptions to this desirable mathematical property include the following:

- XQuery expressions that derive their value from interaction with the external environment. For example, an expression such as `fn:current-time(...)` or `fn:doc(...)` does not necessarily always return the same value, since it depends on external conditions that can change (the time changes; the content of the target document might change).

  In some cases, like that of `fn:doc`, XQuery is defined to be referentially transparent within the execution of a single query: within a query, each invocation of `fn:doc` with the same argument results in the same document.

- XQuery expressions that are defined to be dependent on the particular XQuery language implementation. The result of evaluating such expressions might vary between implementations. Function `fn:doc` is an example of a function that is essentially implementation-defined.

Note that XQuery Update is not in the list; it does *not* present an exception to referential transparency. See "XQuery Update Has Side Effects on Your Data" on page 4-4.

Referential transparency applies also to XQuery *variables*: the same variable in the same context has the same value. Functional languages are like mathematics formalisms in this respect and unlike procedural, or imperative, programming languages. A variable in a procedural language is really a name for a memory location; it has a *current* value, or state, as represented by its content at any time. A variable in a declarative language such as XQuery is really a name for a *static* value.

XQuery Update Has Side Effects on Your Data

Referential transparency applies to the evaluation of XQuery expressions. It does not imply that this evaluation never has a *side effect* on your *data*. In particular, you use XQuery Update to modify your data. That modification is a side effect of evaluating an XQuery updating expression.

The side effect is one thing; the expression value is another. The value returned from evaluation includes the pending update list that describes the updates to carry out. For a given XQuery expression, this description is the same regardless of the context in which evaluation occurs (with the above-mentioned exceptions).

The XQuery Update standard defines how the XDM instances of your data are updated. How those updates are propagated to persistent data stores (for example `XMLType` tables and columns) is implementation-dependent.

XQuery Update Snapshots

An XQuery expression (query) can call for more than one update operation. XQuery Update performs all such operations for the same query as an *atomic* operation: either they all succeed or none of them do (if an error is raised).

The unit of change is thus an entire XQuery query. To effect this atomic update behavior, before evaluating your query XQuery Update takes a **snapshot** of the data (XDM instances) whose modification is called for by the query. It also adds the update operations called for by the query to the pending update list. The snapshot is an evaluation context for an XDM instance that is the update target.

As the last step of XQuery expression evaluation, the pending update list is processed, applying the indicated update operations in an atomic fashion, and terminating the snapshot.

Note that the atomic nature of snapshot semantics means that a set of update operations used in a given query are not necessarily applied in the order written. In fact, the order of applying update operations is fixed and specified by the XQuery Update Feature standard.

This means that *an update operation does not see the result of any other update operation for the same query*. There is no notion of an intermediate or interim update state – all updates for a query are applied together, atomically.

Oracle XML Update Functions (Deprecated) Do Not Use Snapshot Semantics The deprecated Oracle SQL functions for updating XML data (`updateXML` and so on) do *not* use snapshot semantics. This means that if an expression has multiple such function calls they are processed in applicative order (innermost first), and the result of applying one such function is seen by the updating functions applied after it.

This is an important behavior difference between the Oracle updating functions and XQuery Update functions. Besides the semantic difference, there is also a performance difference: in general, the atomic updating of XQuery Update performs better than the incremental updating of the Oracle-specific functions.

XQuery Full Text Provides Full-Text Search

The XQuery and XPath Full Text 1.0 Recommendation (XQuery Full Text) defines XQuery support for full-text searches in queries. It defines full-text selection operators that perform the search and return instances of the AllMatches model, which complements the XQuery Data Model (XDM). An AllMatches instance describes all possible solutions to a full-text query for a given search context item. Each solution is described by a Match instance, which contains the search-context tokens

(StringInclude instances) that must be included and those (StringExclude instances) that must be excluded.

In short, XQuery Full Text adds a full-text contains expression to the XQuery language. You use such an expression in your query to search the text of element nodes and their descendent elements (you can also search the text of attribute nodes).

XQuery Expressions

XQuery expressions are case-sensitive. An XQuery expression is either a *simple* expression or an *updating* expression, the latter being an expression that represents data modification. More precisely, these are the possible XQuery expressions:

- **Basic updating expression –** an `insert`, `delete`, `replace`, or `rename` expression, or a call to an *updating function* (see the XQuery Update Facility 1.0 Recommendation).
- **Updating expression –** a basic updating expression or an expression (other than a transform expression) that contains another updating expression (this is a recursive definition).
- **Simple expression –** An XQuery 1.0 expression. It does not call for any updating.

The pending update list that results from evaluating a simple expression is empty. The sequence value that results from evaluating an updating expression is empty.

Simple expressions include the following:

- **Primary expression –** literal, variable, or function application. A variable name starts with a dollar-sign (`$`) – for example, `$foo`. Literals include numerals, strings, and character or entity references.
- **XPath expression –** Any XPath expression. The XPath 2.0 standard is a subset of XQuery.
- **FLWOR expression –** The most important XQuery expression, composed of the following, in order, from which FLWOR takes its name: `for`, `let`, `where`, `order by`, `return`.
- **XQuery sequence** – The comma (`,`) constructor creates sequences. Sequence-manipulating functions such as `union` and `intersect` are also available. All XQuery sequences are effectively **flat**: a nested sequence is treated as its flattened equivalent. Thus, for instance, `(1, 2, (3, 4, (5), 6), 7)` is treated as `(1, 2, 3, 4, 5, 6, 7)`. A singleton sequence, such as `(42)`, acts the same in most XQuery contexts as does its single item, `42`. Remember that the result of any XQuery expression is a sequence.
- **Direct (literal) constructions** – XML element and attribute syntax automatically constructs elements and attributes: what you see is what you get. For example, the XQuery expression `<a>33</a>` constructs the XML element `<a>33</a>`.
- **Computed (dynamic) constructions –** You can construct XML data at run time using computed values. For example, the following XQuery expression constructs this XML data: `<foo toto="5"><bar>tata titi</bar> why? </foo>`.

  ```
  <foo>attribute toto {2+3},
       element bar {"tata", "titi"},
       text {" why? "}</foo>
  ```

  In this example, element `foo` is a direct construction; the other constructions are computed. In practice, the arguments to computed constructors are not literals (such as `toto` and `"tata"`), but expressions to be evaluated (such as `2+3`). Both the

name and the value arguments of an element or attribute constructor can be computed. Braces ({, }) are used to mark off an XQuery expression to be evaluated.

- **Conditional expression –** As usual, but remember that each part of the expression is itself an arbitrary expression. For instance, in this conditional expression, each of these subexpressions can be any XQuery expression: `something`, `somethingElse`, `expression1`, and `expression2`.

```
if (something < somethingElse) then expression1 else expression2
```

- **Arithmetic, relational expression –** As usual, but remember that each relational expression returns a (Boolean[1]) value. Examples:

```
2 + 3
42 < $a + 5
(1, 4) = (1, 2)
5 > 3 eq true()
```

- **Quantifier expression –** Universal (`every`) and existential (`some`) quantifier functions provide shortcuts to using a FLWOR expression in some cases. Examples:

```
every $foo in doc("bar.xml")//Whatever satisfies $foo/@bar > 42
some $toto in (42, 5), $titi in (123, 29, 5) satisfies $toto = $titi
```

- **Regular expression –** XQuery regular expressions are based on XML Schema 1.0 and Perl. (See Support for XQuery Functions and Operators on page 4-26.)
- **Type expression –** An XQuery expression that represents an XQuery type. Examples: `item()`, `node()`, `attribute()`, `element()`, `document-node()`, `namespace()`, `text()`, `xs:integer`, `xs:string`.[2]

  Type expressions can have **occurrence indicators**: **?** (optional: zero or one), ***** (zero or more), **+** (one or more). Examples: `document-node(element())*`, `item()+`, `attribute()?`.

  XQuery also provides operators for working with types. These include `cast as`, `castable as`, `treat as`, `instance of`, `typeswitch`, and `validate`. For example, `"42" cast as xs:integer` is an expression whose value is the integer 42. (It is not, strictly speaking, a type expression, because its value does not represent a type.)
- **Full-text contains expression** – An XQuery expression that represents a full-text search. This expression is provided by the XQuery and XPath Full Text 1.0 Recommendation. A full-text contains expression (FTContainsExpr) supported by Oracle has these parts: a **search context** that specifies the items to search, and a **full-text selection** that filters those items, selecting matches.

  The selection part is itself composed of the following:

  – **Tokens and phrases** used for matching.

  – Optional **match options**, such as the use of stemming.

  – Optional **Boolean operators** for combining full-text selections.

  – Optional constraint operators, such as **positional filters** (e.g. `ordered window`).

[1] The value returned is a sequence, as always. However, in XQuery, a sequence of one item is equivalent to that item itself. In this case, the single item is a Boolean value.

[2] Namespace prefix `xs` is predefined for the XML Schema namespace, `http://www.w3.org/2001/XMLSchema`.

See "Support for XQuery Full Text" on page 4-27.

FLWOR Expressions

Just as for XQuery in general, there is a lot to learn about FLWOR expressions in particular. This section provides a brief overview.

FLWOR is the most general expression syntax in XQuery. FLWOR (pronounced "flower") stands for `for`, `let`, `where`, `order by`, and `return`. A FLWOR expression has at least one `for` or `let` clause and a `return` clause; single `where` and `order by` clauses are optional. Only the `return` clause can contain an updating expression; the other clauses cannot.

- **`for`** – Bind one or more variables each to any number of values, in turn. That is, for each variable, iterate, binding the variable to a different value for each iteration.

  At each iteration, the variables are bound in the order they appear, so that the value of a variable `$earlier` that is listed before a variable `$later` in the `for` list, can be used in the binding of variable `$later`. For example, during its second iteration, this expression binds `$i` to `4` and `$j` to `6` (2+4):

  ```
  for $i in (3, 4), $j in ($i, 2+$i)
  ```

- **`let`** – Bind one or more variables.

  Just as with `for`, a variable can be bound by `let` to a value computed using another variable that is listed previously in the binding list of the `let` (or an enclosing `for` or `let`). For example, this expression binds `$j` to `5` (3+2):

  ```
  let $i := 3, $j := $i + 2
  ```

- **`where`** – Filter the `for` and `let` variable bindings according to some condition. This is similar to a SQL `WHERE` clause.
- **`order by`** – Sort the result of `where` filtering.
- **`return`** – Construct a result from the ordered, filtered values. This is the result of the FLWOR expression as a whole. It is a flattened sequence.

  If the `return` clause contains an updating expression then that expression is evaluated for each tuple generated by the other clauses. The pending update lists from these evaluations are then merged as the result of the FLWOR expression.

Expressions `for` and `let` act similarly to a SQL `FROM` clause. Expression `where` acts like a SQL `WHERE` clause Expression `order by` is similar to `ORDER BY` in SQL. Expression `return` is like `SELECT` in SQL. Except for the two keywords whose names are the same in both languages (`where`, `order by`), FLWOR clause order is more or less opposite to the SQL clause order, but the meanings of the corresponding clauses are quite similar.

Note that using a FLWOR expression (with `order by`) is the *only* way to construct an XQuery sequence in any order other than document order.

Overview of XQuery in Oracle XML DB

Oracle XML DB support for the XQuery language is provided through a native implementation of SQL/XML functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast`. As a convenience, SQL*Plus command `XQUERY` is also provided, which lets you enter XQuery expressions directly—in effect, this command turns SQL*Plus into an XQuery command-line interpreter.

Oracle XML DB compiles XQuery expressions that are passed as arguments to SQL/XML functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast`. This compilation produces SQL query blocks and operator trees that use SQL/XML functions and XPath functions. A SQL statement that includes `XMLQuery`, `XMLTable`, `XMLExists`, or `XMLCast` is compiled and optimized as a whole, leveraging both relational database and XQuery-specific optimization technologies. Depending on the XML storage and indexing methods used, XPath functions can be further optimized. The resulting optimized operator tree is executed in a streaming fashion.

Note: Oracle XML Developer's Kit (XDK) supports XQuery on the mid-tier. You do not need access to Oracle Database to use XQuery. XDK lets you evaluate XQuery expressions using XQuery API for Java (XQJ).

See Also:

- SQL/XML Functions XMLQUERY, XMLTABLE, XMLExists, and XMLCast and "SQL*Plus XQUERY Command" on page 5-22
- Oracle XQuery Extension Functions for Oracle-specific XQuery functions that extend the language
- Oracle XML DB Support for XQuery for details about Oracle XML DB support for XQuery
- Chapter 5, "Query and Update of XML Data"
- *Oracle XML Developer's Kit Programmer's Guide* for information about using XQJ

When To Use XQuery

You can use XQuery to do many of the same things that you might do using the SQL/XML generation functions or XSLT; there is a great deal of overlap. The decision to use one or the other tool to accomplish a given task can be based on many considerations, most of which are not specific to Oracle Database. Please consult external documentation on this general question.

A general pattern of use is that XQuery is often used when the focus is the world of XML data, and the SQL/XML generation functions (`XMLElement`, `XMLAgg`, and so on) are often used when the focus is the world of relational data.

Other things being equal, if a query constructs an XML document from fragments extracted from existing XML documents, then it is likely that an XQuery FLOWR expression is simpler (simplifying code maintenance) than extracting scalar values from relational data and constructing appropriate XML data using SQL/XML generation functions. If, instead, a query constructs an XML document from existing relational data, the SQL/XML generation functions can often be more suitable.

With respect to Oracle XML DB, you can expect the same general level of performance using the SQL/XML generation functions as with `XMLQuery` and `XMLTable`—all are subject to rewrite optimizations.

Predefined XQuery Namespaces and Prefixes

The following namespaces and prefixes are predefined for use with XQuery in Oracle XML DB:

Table 4–2 Predefined Namespaces and Prefixes

Prefix	Namespace	Description
ora	http://xmlns.oracle.com/xdb	Oracle XML DB namespace
local	http://www.w3.org/2003/11/xpath-local-functions	XPath local function declaration namespace
fn	http://www.w3.org/2003/11/xpath-functions	XPath function namespace
xml	http://www.w3.org/XML/1998/namespace	XML namespace
xs	http://www.w3.org/2001/XMLSchema	XML Schema namespace
xsi	http://www.w3.org/2001/XMLSchema-instance	XML Schema instance namespace

You can use these prefixes in XQuery expressions without first declaring them in the XQuery-expression prolog. You can redefine any of them *except* `xml` in the prolog. All of these prefixes except `ora` are predefined in the XQuery standard.

SQL/XML Functions XMLQUERY, XMLTABLE, XMLExists, and XMLCast

SQL/XML functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast` are defined by the SQL/XML standard as a general interface between the SQL and XQuery languages. They are referred to in this book as SQL/XML *query and update* functions. As is the case for the other SQL/XML functions, these functions let you take advantage of the power and flexibility of both SQL and XML. Using these functions, you can construct XML data using relational data, query relational data as if it were XML, and construct relational data from XML data.

SQL functions `XMLExists` and `XMLCast` are documented elsewhere in this chapter. This section presents functions `XMLQuery` and `XMLTable`, but many of the examples in this chapter use also `XMLExists` and `XMLCast`. In terms of typical use:

- `XMLQuery` and `XMLCast` are typically used in a `SELECT` list.
- `XMLTable` is typically used in a SQL `FROM` clause.
- `XMLExists` is typically used in a SQL `WHERE` clause.

Both `XMLQuery` and `XMLTable` evaluate an XQuery expression. In the XQuery language, an expression always returns a sequence of items. Function `XMLQuery` aggregates the items in this sequence to return a single XML document or fragment. Function `XMLTable` returns a SQL table whose rows each contain one item from the XQuery sequence.

See Also:

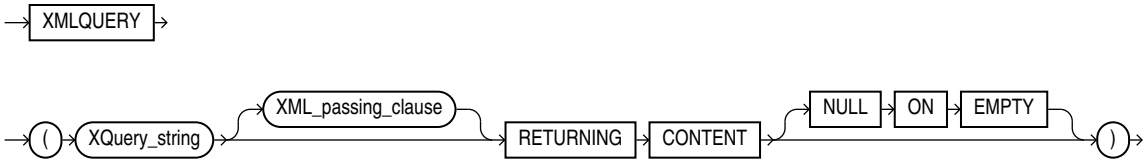
- *Oracle Database SQL Language Reference* for information about Oracle support for the SQL/XML standard
- `http://www.w3.org/` for information about the XQuery language
- "Generation of XML Data Using SQL Functions" on page 8-2 for information about using other SQL/XML functions with Oracle XML DB

XMLQUERY SQL/XML Function in Oracle XML DB

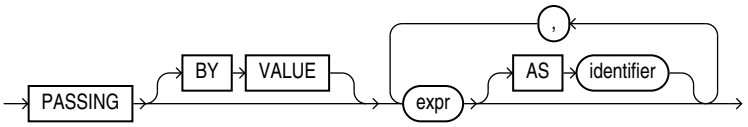
You use SQL/XML function `XMLQuery` to construct or query XML data. This function takes as arguments an *XQuery expression*, as a string literal, and an optional XQuery *context item*, as a SQL expression. The context item establishes the XPath context in

which the XQuery expression is evaluated. Additionally, `XMLQuery` accepts as arguments any number of SQL expressions whose values are bound to XQuery variables during the XQuery expression evaluation. The function returns the result of evaluating the XQuery expression, as an `XMLType` instance.

Figure 4–1 XMLQUERY Syntax



XML_passing_clause ::=



- *XQuery_string* is a complete XQuery expression, possibly including a prolog, as a literal string.
- The *XML_passing_clause* is the keyword `PASSING` followed by one or more SQL expressions (*expr*) that each return an `XMLType` instance or an instance of a SQL scalar data type (that is, not an object or collection data type). Each expression (*expr*) can be a table or view column value, a PL/SQL variable, or a bind variable with proper casting. All but possibly one of the expressions must each be followed by the keyword `AS` and an XQuery *identifier*. The result of evaluating each *expr* is bound to the corresponding *identifier* for the evaluation of *XQuery_string*. If there is an *expr* that is not followed by an `AS` clause, then the result of evaluating that *expr* is used as the *context* item for evaluating *XQuery_string*. Oracle XML DB supports only passing `BY VALUE`, not passing `BY REFERENCE`, so the clause `BY VALUE` is implicit and can be omitted.
- `RETURNING CONTENT` indicates that the value returned by an application of `XMLQuery` is an instance of parameterized XML type `XML(CONTENT)`, not parameterized type `XML(SEQUENCE)`. It is a document fragment that conforms to the *extended* Infoset data model. As such, it is a single document node with any number of children. The children can each be of any XML node type; in particular, they can be text nodes.

  Oracle XML DB supports only the `RETURNING CONTENT` clause of SQL/XML function `XMLQuery`; it does *not* support the `RETURNING SEQUENCE` clause.

You can pass an `XMLType` column, table, or view as the context-item argument to function `XMLQuery`—see, for example, Example 5–8.

To query a relational table or view as if it were XML data, without having to first create a SQL/XML view on top of it, use XQuery function `fn:collection` within an XQuery expression, passing as argument a URI that uses the URI-scheme name `oradb` together with the database location of the data. See "URI Scheme oradb: Querying Table or View Data with XQuery" on page 4-17.

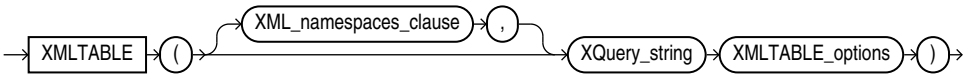
Note: Prior to Oracle Database 11*g* Release 2, some users employed Oracle SQL functions `extract` and `extractValue` to do some of what can be done better using SQL/XML functions `XMLQuery` and `XMLCast`. SQL functions `extract` and `extractValue` are *deprecated* in Oracle Database 11*g* Release 2.

See Also: *Oracle Database SQL Language Reference* for reference information about SQL/XML function `XMLQuery` in Oracle Database

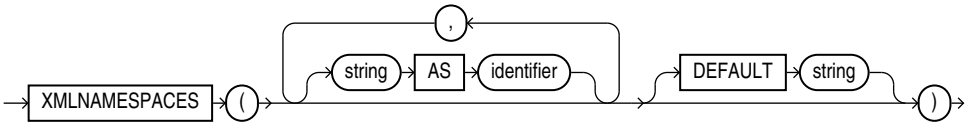
XMLTABLE SQL/XML Function in Oracle XML DB

You use SQL/XML function `XMLTable` to decompose the result of an XQuery-expression evaluation into the relational rows and columns of a new, virtual table. You can then insert the virtual table into a pre-existing database table, or you can query it using SQL—in a join expression, for example (see Example 5–9). You use `XMLTable` in a SQL `FROM` clause.

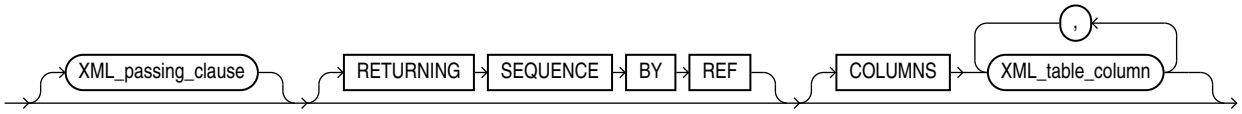
Figure 4–2 XMLTABLE Syntax



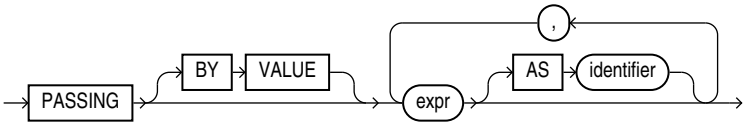
XML_namespaces_clause ::=



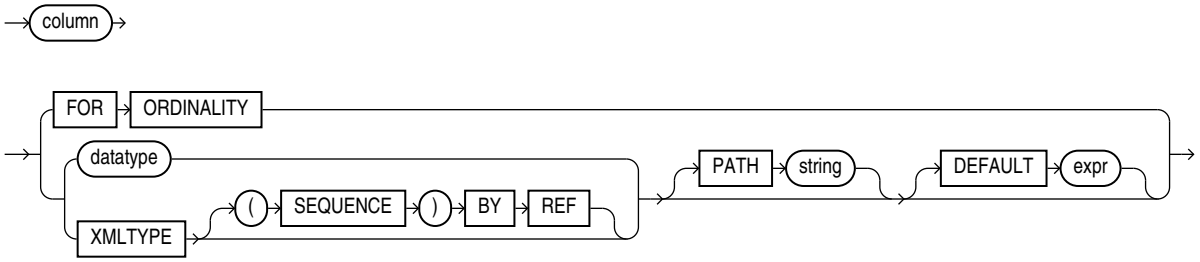
XMLTABLE_options ::=



XML_passing_clause ::=



XML_table_column ::=



- *XQuery_string* is sometimes called the **row pattern** of the XMLTable call. It is a complete XQuery expression, possibly including a prolog, as a literal string. The value of the expression serves as input to the XMLTable function; it is this XQuery result that is decomposed and stored as relational data.
- The optional XMLNAMESPACES clause contains XML namespace declarations that are referenced by *XQuery_string* and by the XPath expression in the PATH clause of *XML_table_column*.
- The *XML_passing_clause* is the keyword PASSING followed by one or more SQL expressions (*expr*) that each return an XMLType instance or an instance of a SQL scalar data type (that is, not an object or collection data type). Each expression (*expr*) can be a table or view column value, a PL/SQL variable, or a bind variables with proper casting. All but possibly one of the expressions must each be followed by the keyword AS and an XQuery *identifier*. The result of evaluating each *expr* is bound to the corresponding *identifier* for the evaluation of *XQuery_string*. If there is an *expr* that is not followed by an AS clause, then the result of evaluating that *expr* is used as the *context* item for evaluating *XQuery_string*. Oracle XML DB supports only passing BY VALUE, not passing BY REFERENCE, so the clause BY VALUE is implicit and can be omitted.
- The optional COLUMNS clause defines the columns of the virtual table to be created by XMLTable.
  - If you omit the COLUMNS clause, then XMLTable returns a row with a single XMLType pseudo-column, named **COLUMN_VALUE**.
  - FOR ORDINALITY specifies that *column* is to be a column of generated row numbers (SQL data type NUMBER). The row numbers start with 1. There must be at most one FOR ORDINALITY clause.
  - For each resulting *column* except the FOR ORDINALITY column, you must specify the column data type, which can be XMLType or any other SQL data type (called *datatype* in the syntax description).
  - For data type XMLType, if you also include the specification (SEQUENCE) BY REF then a *reference* to the source data targeted by the PATH expression (*string*) is returned as the *column* content. Otherwise, *column* contains a *copy* of that targeted data.

    Returning the XMLType data by reference lets you specify other columns whose paths target nodes in the source data that are outside those targeted by the PATH expression for *column*. See Example 5–13.
  - The optional PATH clause specifies that the portion of the XQuery result that is addressed by XQuery expression *string* is to be used as the *column* content. This XQuery expression is sometimes called the **column pattern**. You can use multiple PATH clauses to split the XQuery result into different virtual-table columns.

    If you omit PATH, then the XQuery expression *column* is assumed. For example, these two expressions are equivalent:

    ```
    XMLTable(... COLUMNS foo)
    XMLTable(... COLUMNS foo PATH 'FOO')
    ```

    The XQuery expression *string* must represent a *relative* path; it is relative to the path *XQuery_string*.

- The optional `DEFAULT` clause specifies the value to use when the `PATH` expression results in an empty sequence (or `NULL`). Its *expr* is an XQuery expression that is evaluated to produce the default value.

  See Also: *Oracle Database SQL Language Reference* for reference information about SQL/XML function `XMLTable` in Oracle Database

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Note: Prior to Oracle Database 11*g* Release 2, some users employed Oracle SQL function `XMLSequence` within a SQL `TABLE` collection expression, that is, `TABLE (XMLSequence(...))`, to do some of what can be done better using SQL/XML function `XMLTable`. Function `XMLSequence` is *deprecated* in Oracle Database 11*g* Release 2.

See *Oracle Database SQL Language Reference* for information about the SQL `TABLE` collection expression.

Chaining Calls to SQL/XML Function XMLTABLE

When you need to expose data contained at multiple levels in an `XMLType` table as individual rows in a relational table (or view), you use the same general approach as for breaking up a single level: Use SQL/XML function `XMLTable` to define the columns making up the table and map the XML nodes to those columns.

But in this case you apply function `XMLTable` to each document level that is to be broken up and stored in relational columns. Use this technique of **chaining** multiple `XMLTable` calls whenever there is a one-to-*many* (1:N) relationship between documents in the `XMLType` table and the rows in the relational table.

You pass one level of `XMLType` data from one `XMLTable` call to the next, specifying its column type as `XMLType`.

When you chain two `XMLTable` calls, the *row pattern* of each call should target the *deepest node that is a common ancestor* to all of the nodes that are referenced in the *column patterns* of that call.

This is illustrated in Example 4–1.

Example 4–1 Chaining XMLTable Calls

```
SELECT po.reference, li.*
  FROM po_binaryxml p,
       XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                COLUMNS
                  reference VARCHAR2(30) PATH 'Reference',
                  lineitem  XMLType      PATH 'LineItems/LineItem') po,
       XMLTable('/LineItem' PASSING po.lineitem
                COLUMNS
                  itemno      NUMBER(38)    PATH '@ItemNumber',
                  description VARCHAR2(256) PATH 'Description',
                  partno      VARCHAR2(14)  PATH 'Part/@Id',
                  quantity    NUMBER(12, 2) PATH 'Part/@Quantity',
                  unitprice   NUMBER(8, 4)  PATH 'Part/@UnitPrice') li;
```

Each `PurchaseOrder` element in `XMLType` table `po_binaryxml` contains a `LineItems` element, which in turn contains one or more `LineItem` elements. Each `LineItem` element has child elements, such as `Description`, and an `ItemNumber` attribute. To make such lower-level data accessible as a relational value, you use `XMLTable` to project the collection of `LineItem` elements.

When element `PurchaseOrder` is decomposed by the first call to `XMLTable`, its descendant `LineItem` element is mapped to a column of type `XMLType`, which contains an XML fragment. That column is then passed to a second call to `XMLTable` to be broken by it into its various parts as multiple columns of relational values.

The first call to `XMLTable` uses `/PurchaseOrder` as the row pattern, because `PurchaseOrder` is the deepest common ancestor node for the column patterns, `Reference` and `LineItems/LineItem`.

The second call to `XMLTable` uses `/LineItem` as its row pattern, because that node is the deepest common ancestor node for each of its column patterns (`@ItemNumber`, `Description`, `Part/@Id`, and so on).

The *column pattern* (`LineItems/LineItem`) for the column (`po.lineitem`) that is passed from the first `XMLTable` call t o the second *ends with the repeating element* (`LineItem`) that the second `XMLTable` call decomposes. That repeating element, written with a leading slash (`/`), is used as the first element of the *row pattern* for the second `XMLTable` call.

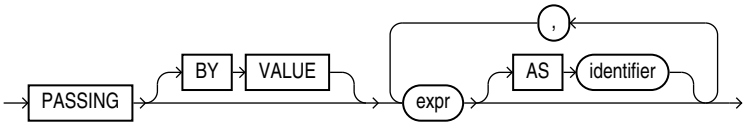
The row pattern in each case is thus expressed as an *absolute* path; that is, it starts with `/`. It is the starting point for decomposition by `XMLTable`. Column patterns, on the other hand, *never* start with a slash (`/`); they are always relative to the row pattern of the same `XMLTable` call.

XMLEXISTS SQL/XML Function in Oracle XML DB

Figure 4–3 describes the syntax for SQL/XML standard function `XMLExists`. This function checks whether a given XQuery expression returns a non-empty XQuery sequence. If so, the function returns `TRUE`. Otherwise, it returns `FALSE`.

Figure 4–3 XMLExists Syntax

XML_passing_clause ::=



- *`XQuery_string`* is a complete XQuery expression, possibly including a prolog, as a literal string. It can contain XQuery variables that you bind using the XQuery `PASSING` clause (*`XML_passing_clause`* in the syntax diagram). The predefined namespace prefixes recognized for SQL/XML function `XMLQuery` are also recognized in *`XQuery_string`*—see "Predefined XQuery Namespaces and Prefixes" on page 4-8.
- The *`XML_passing_clause`* is the keyword `PASSING` followed by one or more SQL expressions (*`expr`*) that each return an `XMLType` instance or an instance of a SQL scalar data type. All but possibly one of the expressions must each be followed by the keyword `AS` and an XQuery *`identifier`*. The result of evaluating each *`expr`* is bound to the corresponding *`identifier`* for the evaluation of *`XQuery_string`*. If there is an *`expr`* that is not followed by an `AS` clause, then the result of evaluating that *`expr`* is used as the *context* item for evaluating *`XQuery_string`*. Oracle XML DB supports only passing `BY VALUE`, not passing `BY REFERENCE`, so the clause `BY VALUE` is implicit and can be omitted.

If an XQuery expression such as `/PurchaseOrder/Reference` or `/PurchaseOrder/Reference/text()` targets a single node, then `XMLExists` returns `true` for that expression. If `XMLExists` is called with an XQuery expression that locates no nodes, then `XMLExists` returns `false`.

Function `XMLExists` can be used in queries, and it can be used to create function-based indexes to speed up evaluation of queries.

Note: Oracle XML DB limits the use of `XMLExists` to a SQL `WHERE` clause or `CASE` expression. If you need to use `XMLExists` in a `SELECT` list, then wrap it in a `CASE` expression:

```
CASE WHEN XMLExists(...) THEN 'TRUE' ELSE 'FALSE' END
```

Example 4–2 uses SQL/XML standard function `XMLExists` to select rows with `SpecialInstructions` set to `Expedite`.

Example 4–2 Finding a Node Using SQL/XML Function XMLExists

```
SELECT OBJECT_VALUE
  FROM purchaseorder
  WHERE XMLExists('/PurchaseOrder[SpecialInstructions="Expedite"]'
                  PASSING OBJECT_VALUE);

OBJECT_VALUE
----------------------------------------------------------------------
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

13 rows selected.
```

You can create function-based indexes using SQL/XML function `XMLExists` to speed up the execution. You can also create an `XMLIndex` index to help speed up arbitrary XQuery searching.

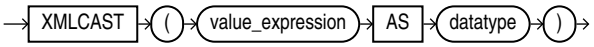
Note: Prior to Oracle Database 11*g* Release 2, some users employed Oracle SQL function `existsNode` to do some of what can be done better using SQL/XML function `XMLExists`. Function `existsNode` is *deprecated* in Oracle Database 11*g* Release 2. The two functions differ in these important ways:

- Function `existsNode` returns `0` or `1`. Function `XMLExists` returns a Boolean value, `TRUE` or `FALSE`.
- You can use `existsNode` in a query `SELECT` list. You cannot use `XMLExists` directly in a `SELECT` list, but you can use `XMLExists` within a `CASE` expression in a `SELECT` list.

XMLCAST SQL/XML Function in Oracle XML DB

Figure 4–4 describes the syntax for SQL/XML standard function `XMLCast`.

Figure 4–4 XMLCast Syntax



SQL/XML standard function `XMLCast` casts its first argument to the scalar SQL data type specified by its second argument. The first argument is a SQL expression that is evaluated. Any of the following SQL data types can be used as the second argument:

- `NUMBER`
- `VARCHAR2`
- `CHAR`
- `CLOB`
- `BLOB`
- `REF XMLTYPE`
- any SQL date or time data type

Note: Unlike the SQL/XML standard, Oracle XML DB limits the use of `XMLCast` to cast XML to a SQL scalar data type. Oracle XML DB does not support casting XML to XML or from a scalar SQL type to XML.

The result of evaluating the first `XMLCast` argument is an XML value. It is converted to the target SQL data type by using the XQuery atomization process and then casting the XQuery atomic values to the target data type. If this conversion fails, then an error is raised. If conversion succeeds, the result returned is an instance of the target data type.

The query in Example 4–3 extracts the scalar value of node `Reference`.

Example 4–3 Extracting the Scalar Value of an XML Fragment Using XMLCAST

```
SELECT XMLCast(XMLQuery('/PurchaseOrder/Reference' PASSING OBJECT_VALUE
                                                   RETURNING CONTENT)
               AS VARCHAR2(100)) "REFERENCE"
```

```
  FROM purchaseorder
  WHERE XMLExists('/PurchaseOrder[SpecialInstructions="Expedite"]'
                  PASSING OBJECT_VALUE);

REFERENCE
----------------------------
AMCEWEN-20021009123336271PDT
SKING-20021009123336321PDT
AWALSH-20021009123337303PDT
JCHEN-20021009123337123PDT
AWALSH-20021009123336642PDT
SKING-20021009123336622PDT
SKING-20021009123336822PDT
AWALSH-20021009123336101PDT
WSMITH-20021009123336412PDT
AWALSH-20021009123337954PDT
SKING-20021009123338294PDT
WSMITH-20021009123338154PDT
TFOX-20021009123337463PDT

13 rows selected.
```

Note:

- Prior to Oracle Database 11*g* Release 2, some users employed Oracle SQL function `extractValue` to do some of what can be done better using SQL/XML functions `XMLQuery` and `XMLCast`. Function `extractValue` is *deprecated* in Oracle Database 11*g* Release 2.
- Function `extractValue` raises an error when its XPath expression argument matches multiple text nodes. `XMLCast` applied to an `XMLQuery` result returns the concatenation of the text nodes—it does *not* raise an error.

See Also:

- "Indexing XMLType Data Stored Object-Relationally" on page 6-54
- "XMLIndex" on page 6-6

URI Scheme oradb: Querying Table or View Data with XQuery

You can use XQuery functions `fn:doc` and `fn:collection` to query resources in Oracle XML DB Repository—see"Querying XML Data in Oracle XML DB Repository Using XQuery" on page 5-3. This section is about using XQuery function `fn:collection` to query data in database tables and views.

To do this, you pass function `fn:collection` a URI argument that specifies the table or view to query. The Oracle URI scheme `oradb` identifies this usage: without it, the argument is treated as a repository location.

The table or view that is queried can be relational or of type `XMLType`. If relational, its data is converted on the fly and treated as XML. The result returned by `fn:collection` is always an XQuery sequence.

- For an `XMLType` table, the root element of each XML document returned by `fn:collection` is the same as the root element of an XML document in the table.

- For a relational table, the root element of each XML document returned by `fn:collection` is `ROW`. The children of the `ROW` element are elements with the same names (uppercase) as columns of the table. The content of a child element corresponds to the column data. That content is an XML element if the column is of type `XMLType`; otherwise (the column is a scalar type), the content is of type `xs:string`.

The format of the URI argument passed to `fn:collection` is as follows:

- For an `XMLType` or relational table or view, *`TABLE`*, in database schema *`DB-SCHEMA`*:

  `oradb:``/`*`DB-SCHEMA`*`/`*`TABLE`*`/`

  You can use **`PUBLIC`** for *`DB-SCHEMA`* if *`TABLE`* is a public synonym or *`TABLE`* is a table or view that is accessible to the database user currently logged in.

- For an `XMLType` column in a *relational* table or view:

  `oradb:``/`*`DB-SCHEMA`*`/`*`REL-TABLE`*`/`**`ROW`***`PRED`*`/`*`X-COL`*

  `REL-TABLE` is a relational table or view; *`PRED`* is an XPath predicate that does not involve any `XMLType` columns; and *`X-COL`* is an `XMLType` column in *`REL-TABLE`*. *`PRED`* is optional; *`DB-SCHEMA`*, *`REL-TABLE`*, and *`X-COL`* are required.

Optional XPath predicate *`PRED`* must satisfy the following conditions:

- It does not involve any `XMLType` columns.
- It involves only conjunctions (`and`) and disjunctions (`or`) of general equality and inequality comparisons (`=`, `!=`, `>`, `<`, `>=`, and `<=`).
- For each comparison operation: Either both sides name (non-XML) columns in *`REL-TABLE`* or one side names such a column and the other is a value of the proper type, as specified in Table 4–3. Use of any other type raises an error.

Table 4–3 oradb Expressions: Column Types for Comparisons

Relational Column Type	XQuery Value Type
`VARCHAR2`, `CHAR`	`xs:string` or string literal
`NUMBER`, `FLOAT`, `BINARY_FLOAT`, `BINARY_DOUBLE`	`xs:decimal`, `xs:float`, `xs:double`, or numeric literal
`DATE`, `TIMESTAMP`, `TIMESTAMP WITH TIMEZONE`, `TIMESTAMP WITH LOCAL TIMEZONE`	`xs:date`, `xs:time`, or `xs:dateTime`
`INTERVAL YEAR TO MONTH`	`xs:yearMonthDuration`
`INTERVAL DAY TO SECOND`	`xs:dayTimeDuration`
`RAW`	`xs:hexBinary`
`ROWID`	`xs:string` or string literal

For example, this XQuery expression represents all XML documents in `XMLType` column `warehouse_spec` of table `oe.warehouses`, for the rows where column `warehouse_id` has a value less than 6:

```
fn:collection('oradb:/OE/WAREHOUSES/ROW[WAREHOUSE_ID < 6]/WAREHOUSE_SPEC')
```

See Also: "Querying Relational Data Using XQuery and URI Scheme oradb" on page 5-5

Oracle XQuery Extension Functions

Oracle XML DB adds some XQuery functions to those provided in the W3C standard. These additional functions are in the Oracle XML DB namespace, `http://xmlns.oracle.com/xdb`, which uses the predefined prefix **`ora`**. This section describes these Oracle extension functions.

Note: Prior to Oracle Database 12*c* Release 1, standard XQuery functions `fn:matches` and `fn:replace` were not supported, and Oracle XML DB provided these Oracle XQuery functions to use in their stead: `ora:matches` and `ora:replace`. These Oracle XQuery functions are *deprecated* in Oracle Database 12*c* Release 1 – use the standard XQuery functions (namespace prefix `fn`) instead.

---

ora:contains XQuery Function

ora:contains Syntax

```
ora:contains (input_text, text_query [, policy_name] [, policy_owner])
```

Oracle XQuery and XPath function `ora:contains` can be used in an XQuery expression in a call to SQL/XML function `XMLQuery`, `XMLTable`, or `XMLExists`. It is used to restrict a structural search with a full-text predicate. Function `ora:contains` returns a positive integer when the *`input_text`* matches *`text_query`* (the higher the number, the more relevant the match), and zero otherwise. When used in an XQuery expression (that is not also an XPath expression), the XQuery return type is `xs:integer()`; when used in an XPath expression outside of an XQuery expression, the XPath return type is `number`.

Argument *`input_text`* must evaluate to a single text node or an attribute. The syntax and semantics of *`text_query`* in `ora:contains` are the same as *`text_query`* in `contains`, with a few restrictions.

See Also: "ora:contains XQuery Function" on page E-17

ora:sqrt XQuery Function

ora:sqrt Syntax

```
ora:sqrt (number)
```

Oracle XQuery function `ora:sqrt` returns the square root of its numeric argument, which can be of XQuery type `xs:decimal`, `xs:float`, or `xs:double`. The returned value is of the same XQuery type as the argument.

ora:tokenize XQuery Function

ora:tokenize Syntax

```
ora:tokenize (target_string, match_pattern [, match_parameter])
```

Oracle XQuery function `ora:tokenize` lets you use a regular expression to split the input string *`target_string`* into a sequence of strings. It treats each substring that matches the regular-expression *`match_pattern`* as a separator indicating where to split.

It returns the sequence of tokens as an XQuery value of type `xs:string*` (a sequence of `xs:string` values). If *`target_string`* is the empty sequence, it is returned. Optional argument *`match_parameter`* is a code that qualifies matching: case-sensitivity and so on.

The argument types are as follows:

- *`target_string`* – `xs:string?`[3]
- *`match_pattern`* – `xs:string`
- *`match_parameter`* – `xs:string`

ora:matches XQuery Function (Deprecated)

This Oracle XQuery function is *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1) – use standard XQuery function `fn:matches` instead.

ora:matches Syntax

```
ora:matches (target_string, match_pattern [, match_parameter])
```

Oracle XQuery function `ora:matches` lets you use a regular expression to match text in a string. It returns `true()` if its *`target_string`* argument matches its regular-expression *`match_pattern`* argument and `false()` otherwise. If *`target_string`* is the empty sequence, `false()` is returned. Optional argument *`match_parameter`* is a code that qualifies matching: case-sensitivity and so on.

The behavior of XQuery function `ora:matches` is the same as that of SQL condition `REGEXP_LIKE`, but the types of its arguments are XQuery types instead of SQL data types. The argument types are as follows:

- *`target_string`* – `xs:string?`[4]
- *`match_pattern`* – `xs:string`
- *`match_parameter`* – `xs:string`

> **See Also:** *Oracle Database SQL Language Reference* for information about SQL condition `REGEXP_LIKE`

ora:replace XQuery Function (Deprecated)

This Oracle XQuery function is *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1) – use standard XQuery function `fn:replace` instead.

ora:replace Syntax

```
ora:replace (target_string, match_pattern, replace_string [, match_parameter])
```

Oracle XQuery function `ora:replace` lets you use a regular expression to replace matching text in a string. *Each* occurrence in *`target_string`* that matches regular-expression *`match_pattern`* is replaced by *`replace_string`*. It returns the new string that results from the replacement. If *`target_string`* is the empty sequence, then the empty string (`""`) is returned. Optional argument *`match_parameter`* is a code that qualifies matching: case-sensitivity and so on.

[3] The question mark (`?`) here is a zero-or-one occurrence indicator that indicates that the argument can be the empty sequence. See "XQuery Expressions" on page 4-5.

[4] The question mark (`?`) here is a zero-or-one occurrence indicator that indicates that the argument can be the empty sequence. See "XQuery Expressions" on page 4-5.

The behavior of XQuery function `ora:replace` is the same as that of SQL function `regexp_replace`, but the types of its arguments are XQuery types instead of SQL data types. The argument types are as follows:

- *target_string* – `xs:string?`[5]
- *match_pattern* – `xs:string`
- *replace_string* – `xs:string`
- *match_parameter* – `xs:string`

In addition, `ora:replace` requires argument *replace_string* (it is optional in `regexp_replace`) and it does not use arguments for position and number of occurrences – search starts with the first character and all occurrences are replaced.

> **See Also:** *Oracle Database SQL Language Reference* for information about SQL function `regexp_replace`

Oracle XQuery Extension-Expression Pragmas

The W3C XQuery specification lets an implementation provide implementation-defined extension expressions. An XQuery extension expression is an XQuery expression that is enclosed in braces (`{`, `}`) and prefixed by an implementation-defined pragma.

The Oracle implementation provides the pragmas described in this section. No other pragmas are recognized than those listed here. Use of any other pragma, or use of any of these pragmas with incorrect pragma content (for example, `(#ora:view_on_null something_else #)`), raises an error.

In the `ora:view_on_null` examples here, assume that table `null_test` has columns `a` and `b` of type `VARCHAR2(10)`, and that column `b` (but not `a`) is empty.

- `(#ora:child-element-name` *name* `#)` – Specify the name to use for a child element that is inserted. In general, without this pragma the name of the element to be inserted is unknown at compile time. Specifying the name allows for compile-time optimization, to improve runtime performance.

  As an example, the following SQL statement specifies `LineItem` as the name of the element node that is inserted as a child of element `LineItems`. The element data to be inserted is the value of XQuery variable `p2`, which comes from bind variable `:1`.

```
UPDATE oe.purchaseorder p SET p.OBJECT_VALUE =
  XMLQuery(
    'copy $i :=
       $p1 modify (for $j in $i/PurchaseOrder/LineItems
                     return (#ora:child-element-name LineItem #)
                            {insert node $p2 into $j)
                   return $i'
    PASSING p.OBJECT_VALUE AS "p1", :1 AS "p2" RETURNING CONTENT)
  WHERE XMLQuery(
          '/PurchaseOrder/Reference/text()'
          PASSING p.OBJECT_VALUE RETURNING CONTENT).getStringVal() =
            'EMPTY_LINES';
```

  This pragma applies to `XMLType` data stored either object-relationally or as binary XML.

[5] The question mark (`?`) here is a zero-or-one occurrence indicator that indicates that the argument can be the empty sequence. See "XQuery Expressions" on page 4-5.

- `(#ora:defaultTable #)` – Specify the default table used to store repository data. Use this to improve the performance of repository queries that use Query function `fn:doc` or `fn:collection`. See "Using Oracle XQuery Pragma ora:defaultTable" on page 5-46.
- `(#ora:invalid_path empty #)` – Treat an invalid XPath expression as if its targeted nodes do not exist. For example:

```
SELECT XMLQuery('(#ora:invalid_path empty #)
                 {exists($p/PurchaseOrder//NotInTheSchema)}'
                PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM oe.purchaseorder p;
```

  The XML schema for table `oe.purchaseorder` does not allow any such node `NotInTheSchema` as a descendant of node `PurchaseOrder`. Without the pragma, the use of this invalid XPath expression would raise an error. But with the pragma, the calling context acts just as if the XPath expression had targeted no nodes. That calling context in this example is XQuery function `exists`, which returns XQuery Boolean value `false` when passed an empty node sequence. (XQuery function `exists` is used in this example only to illustrate the behavior; the pragma is not especially related to function `exists`.)

- `(#ora:view_on_null empty #)` – XQuery function `fn:collection` returns an empty XML element for each `NULL` column. For example, the following query returns `<ROW><A>x</A><B></B></ROW>`:

```
SELECT XMLQuery('(#ora:view_on_null empty #)
                 {for $i in fn:collection("oradb:/PUBLIC/NULL_TEST")/ROW
                  return $i}'
                RETURNING CONTENT)
  FROM DUAL;
```

- `(#ora:view_on_null null #)` – XQuery function `fn:collection` returns no element for a `NULL` column. For example, the following query returns `<ROW><A>x</A></ROW>`:

```
SELECT XMLQuery('(#ora:view_on_null null #)
                 {for $i in fn:collection("oradb:/PUBLIC/NULL_TEST")/ROW
                  return $i}'
                RETURNING CONTENT)
  FROM DUAL;
```

- `(#ora:no_xmlquery_rewrite #)`[6] – Do not optimize XQuery procedure calls in the XQuery expression that follows the pragma; use functional evaluation instead.

  This has the same effect as the SQL hint `/*+ NO_XML_QUERY_REWRITE */`, but the scope of the pragma is only the XQuery expression that follows it (not an entire SQL statement).

  > **See Also:** "Turning Off Use of XMLIndex" on page 6-32 for information about optimizer hint `NO_XML_QUERY_REWRITE`

- `(#ora:xmlquery_rewrite #)`[6] – Try to optimize the XQuery expression that follows the pragma. That is, if possible, do not evaluate it functionally.

[6] Prior to Oracle Database 12*c* Release 1 (12.1.0.1), pragmas `ora:no_xmlquery_rewrite` and `ora:xmlquery_rewrite` were named `ora:xq_proc` and `ora:xq_qry`, respectively. They were renamed for readability, with no change in meaning.

As an example of using both `ora:no_xmlquery_rewrite` and `ora:xmlquery_rewrite`, in the following query the XQuery expression argument to `XMLQuery` will in general be evaluated functionally, but the `fn:collection` subexpressions that are preceded by pragma `ora:xmlquery_rewrite` will be optimized, if possible.

```
SELECT XMLQuery('(#ora:no_xmlquery_rewrite#) (: Do not optimize expression :)
                 {for $i in (#ora:xmlquery_rewrite#) (: Optimize subexp. :)
                           {fn:collection("oradb:/HR/REGIONS")},
                      $j in (#ora:xmlquery_rewrite#) (: Optimize subexpr. :)
                           {fn:collection("oradb:/HR/COUNTRIES")}
                  where $i/ROW/REGION_ID = $j/ROW/REGION_ID
                    and $i/ROW/REGION_NAME = $regionname
                  return $j}'
         PASSING CAST('&REGION' AS VARCHAR2(40)) AS "regionname"
           RETURNING CONTENT)
  AS asian_countries FROM DUAL;
```

- `(#ora:no_schema #)` – Do not raise an error if an XQuery Full Text expression is used with XML Schema-based `XMLType` data. Instead, implicitly cast the data to non XML-Schema-based data. In particular, this means ignore XML Schema data types.

  Oracle supports XQuery Full Text only for `XMLType` data stored as binary XML, so this pragma applies only for the same case.

- `(#ora:use_xmltext_idx #)` – Use an XML search index, if available, to evaluate the query. Do not use an `XMLIndex` index or streaming evaluation.

  An XML search index applies only to `XMLType` data stored as binary XML, so this pragma does also.

- `(#ora:transform_keep_schema #)` – Retain XML Schema information for the documents returned by the XQuery expression that follows the pragma. This is useful for XQuery Update, which uses copy semantics.

  Without the pragma, when XML schema-based data is copied during an XQuery Update operation, the XML schema information is lost. This is the behavior specified by the XQuery Update standard. If you then try to insert the updated data into an XML schema-based column or table then an error is raised: the data to be inserted is untyped, so it does not conform to the XML schema.

  If you use the pragma then the data retains its XML schema information, preventing the insertion error. Here is an example of using the pragma:

```
SELECT XMLQuery('declare default element namespace
                 "http://xmlns.oracle.com/xdb/xdbconfig.xsd"; (: :)
                 (#ora:transform_keep_schema#)
                 {copy $NEWXML :=
                   $XML modify (for $CFG in $NEWXML/xdbconfig//httpconfig
                                  return (replace value of node
                                          $CFG/http-port with xs:int($PORTNO)))
                              return $NEWXML}'
                PASSING CFG AS "XML", 81 as "PORTNO" RETURNING CONTENT)
  FROM DUAL;
```

XQuery Static Type-Checking in Oracle XML DB

Oracle XML DB type-checks *all* XQuery expressions. Doing this at run time can be costly, however. As an optimization technique, whenever there is sufficient static type information available for a given query at compile time, Oracle XML DB performs *static* (compile time) type-checking of that query. Whenever sufficient static type

information is not available for a given query at compile time, Oracle XML DB uses dynamic (run-time) type checking for that query.

Static type-checking can save execution time by raising errors at compile time. Static type-checking errors include both data-type errors and the use of XPath expressions that are invalid with respect to an XML schema.

Typical ways of providing sufficient static type information at query compile time include the following:

- Using XQuery with `fn:doc` or `fn:collection` over relational data.
- Using XQuery to query an `XMLType` table, column, or view whose XML Schema information is available at query compile time.
- Using XQuery Update with a transform expression whose input is from an `XMLType` table or column that is based on an XML schema.

This section presents examples that demonstrate the utility of static type-checking and the use of these two means of communicating type information.

The XML data produced on the fly by `fn:collection` together with URI scheme `oradb` has `ROW` as its top-level element, but the query of Example 4–4 incorrectly lacks that `ROW` wrapper element. This omission raises a query compile-time error. Forgetting that `fn:collection` with `oradb` wraps relational data in this way is an easy mistake to make, and one that could be difficult to diagnose without static type-checking. Example 5–5 shows the correct code.

Example 4–4 Static Type-Checking of XQuery Expressions: oradb URI scheme

```
-- This produces a static-type-check error, because "ROW" is missing.
SELECT XMLQuery('for $i in fn:collection("oradb:/HR/REGIONS"),
                     $j in fn:collection("oradb:/HR/COUNTRIES")
                 where $i/REGION_ID = $j/REGION_ID and $i/REGION_NAME = "Asia"
                 return $j'
                RETURNING CONTENT) AS asian_countries
  FROM DUAL;
SELECT XMLQuery('for $i in fn:collection("oradb:/HR/REGIONS"),
*
ERROR at line 1:
ORA-19276: XPST0005 - XPath step specifies an invalid element/attribute name:
(REGION_ID)
```

In Example 4–5, XQuery static type-checking finds a mismatch between an XPath expression and its target XML schema-based data. Element `CostCenter` is misspelled here as `costcenter` (XQuery and XPath are case-sensitive). Example 5–11 shows the correct code.

Example 4–5 Static Type-Checking of XQuery Expressions: XML Schema-Based Data

```
-- This results in a static-type-check error: CostCenter is not the right case.
SELECT xtab.poref, xtab.usr, xtab.requestor
  FROM purchaseorder,
       XMLTable('for $i in /PurchaseOrder where $i/costcenter eq "A10" return $i'
                PASSING OBJECT_VALUE
                COLUMNS poref     VARCHAR2(20) PATH 'Reference',
                        usr       VARCHAR2(20) PATH 'User' DEFAULT 'Unknown',
                        requestor VARCHAR2(20) PATH 'Requestor') xtab;
  FROM purchaseorder,
       *
ERROR at line 2:
ORA-19276: XPST0005 - XPath step specifies an invalid element/attribute name:
```

```
(costcenter)
```

Oracle XML DB Support for XQuery

This section describes Oracle XML DB support for the XQuery language.

Support for XQuery and SQL

Support for the XQuery language in Oracle XML DB is designed to provide the best fit between the worlds of relational storage and querying XML data. That is, Oracle XML DB is a general XQuery implementation, but it is in addition specifically designed to make relational and XQuery queries work well together.

The specific properties of the Oracle XML DB XQuery implementation are described in this section. The XQuery standard explicitly calls out certain aspects of the language processing as implementation-defined or implementation-dependent. There are also some features that are specified by the XQuery standard but are not supported by Oracle XML DB.

See Also: "Support for XQuery Full Text" on page 4-27

Implementation Choices Specified in the XQuery Standards

The XQuery standards specify that each of the following aspects of language processing is to be defined by the implementation.

- *Implicit time zone support* – In Oracle XML DB, the implicit time zone is always assumed to be `Z`, and instances of `xs:date`, `xs:time`, and `xs:datetime` that are missing time zones are automatically converted to UTC.
- *`copy-namespaces` default value* – The default value for a `copy-namespaces` declaration (used in XQuery Update) is `inherit`.
- *Revalidation mode* – The default mode for XQuery Update transform expression revalidation is `skip`. However, if the result of a transform expression is an update to XML schema-based data in an `XMLType` table or column, then XML schema validation is enforced.

XQuery Features Not Supported by Oracle XML DB

The following features specified by the XQuery standard are not supported by Oracle XML DB:

- *Copy-namespace mode* – Oracle XML DB supports only `preserve` and `inherit` for a `copy-namespaces` declaration. If an existing element node is copied by an element constructor or a document constructor, all in-scope namespaces of the original element are retained in the copy. Otherwise, the copied node inherits all in-scope namespaces of the constructed node. An error is raised if you specify `no-preserve` or `no-inherit`.
- *Version encoding* – Oracle XML DB does not support an optional encoding declaration in a version declaration. That is, you cannot include `(encoding` *`an-encoding`*`)` in a declaration `xquery version` *`a-version`*`;`. In particular, you cannot specify an encoding used in the query. An error is raised if you include an encoding declaration.
- *xml:id* – Oracle XML DB does not support use of `xml:id`. If you use `xml:id`, then an error is raised.
- XQuery prolog default-collation declaration.

- XQuery prolog boundary-space declaration.
- XQuery data type `xs:duration`. Use either `xs:yearMonthDuration` or `xs:DayTimeDuration` instead.
- XQuery Update function `fn:put`.

XQuery Optional Features

The following optional features specified by the XQuery standard are *not* supported by Oracle XML DB:

- Schema Validation Feature
- Module Feature

The following optional XQuery features are supported by Oracle XML DB:

- XQuery Static Typing Feature
- XQuery Update Static Typing Feature

> **See Also:** "XQuery Static Type-Checking in Oracle XML DB" on page 4-23

Support for XQuery Functions and Operators

Oracle XML DB supports all of the XQuery functions and operators included in the latest *XQuery 1.0 and XPath 2.0 Functions and Operators* specification, with the following exceptions. There is *no* support for the following:

- Function `fn:tokenize`. Use Oracle XQuery function `ora:tokenize` instead.
- Functions `fn:id` and `fn:idref`.
- Function `fn:collection` without arguments.
- Optional collation parameters for XQuery functions.

XQuery Functions fn:doc, fn:collection, and fn:doc-available

Oracle XML DB supports XQuery functions `fn:doc`, `fn:collection`, and `fn:doc-available` for all resources in Oracle XML DB Repository.

Function `fn:doc` returns the repository *file* resource that is targeted by its URI argument; it must be a file of well-formed XML data. Function `fn:collection` is similar, but works on repository *folder* resources (each file in the folder must contain well-formed XML data).

When used with Oracle URI scheme `oradb`, `fn:collection` can return XML data derived on the fly from existing relational data that is not in the repository.

XQuery function `fn:collection` raises an error when used with URI scheme `oradb`, if its targeted table or view, or a targeted column, does not exist. Functions `fn:doc` and `fn:collection` do *not* raise an error if the repository resource passed as argument is not found. Instead, they return an empty sequence.

You can determine whether a given document exists using XQuery function `fn:doc-available`. It returns `true` if its document argument exists, `false` if not.

> **See Also:** `http://www.w3.org/` for the definitions of XQuery functions and operators

Support for XQuery Full Text

This section describes Oracle support for the XQuery and XPath Full Text 1.0 Recommendation (hereafter XQuery Full Text, or XQFT). Refer to that standard for information about any terms that are not detailed here.

Oracle supports XQuery Full Text *only* for `XMLType` data that is stored as *binary XML*. You can perform a full-text search of `XMLType` data that is stored object-relationally using an Oracle Text index, but not using XQuery Full Text.

A general rule for understanding Oracle support for XQuery Full Text is that the Oracle implementation of XQFT is based on Oracle Text, which provides full-text indexing and search for Oracle products and for applications developed using them. The XQFT support details provided in this section are a consequence of this Oracle Text based implementation.

See Also:

- *Oracle Text Application Developer's Guide*
- *Oracle Text Reference*
- Appendix E, "Full-Text Search over XML Data Without XQuery" for information about performing a full-text search of `XMLType` data stored object-relationally

XQuery Full Text, XML Schema-Based Data, and Pragma ora:no_schema

You can use XQuery Full Text to query `XMLType` data that is stored as binary XML. However, if you use it with XML Schema-based data then you must also use the XQuery extension-expression pragma `ora:no_schema` in your query, or else an error is raised.

And if you use `ora:no_schema` then, for purposes of XQuery Full Text, the XML data is implicitly cast to non XML Schema-based data. In other words, Oracle support of XQuery Full Text treats all XML data as if it were not based on an XML schema.

In particular, this means that if you include in your query an XQuery Full Text condition that makes use of XML Schema data types, such type considerations are ignored. A comparison of two XML Schema date values, for instance, is handled as a simple string comparison. Oracle support for XQuery Full Text is not XML Schema-aware.

See Also: "Pragma ora:no_schema: Using XML Schema-Based Data with XQuery Full Text" on page 6-51

Restrictions on Using XQuery Full Text with XMLExists

You can pass only one `XMLType` instance as a SQL expression in the `PASSING` clause of SQL/XML function `XMLExists`, and each of the other, non-`XMLType` SQL expressions in that clause must be either a *compile-time constant* of a SQL built-in data type or a *bind variable* that is bound to an instance of such a data type. If this restriction is not respected then compile-time error ORA-18177 is raised.

Supported XQuery Full Text FTSelection Operators

Oracle XML DB supports *only* the following XQuery Full Text FTSelection operators. Any applicable restrictions are noted. Use of the terms "must" and "must not" means that an error is raised if the specified restriction is not respected. Use of any operators not listed here raises an error.

- FTAnd (`ftand`)

- FTMildNot (`not in`)

  Each operand for operator FTMildNot must be either a term or a phrase, that is, an instance of FTWords. It must not be an expression. Oracle handles FTMildNot the same way it handles Oracle Text operator `MNOT`.

- FTOr (`ftor`)
- FTOrder (`ordered`)

  Oracle supports the use of FTOrder *only* when used in the context of a window (FTWindow). Otherwise, it is not supported. For example, you can use `ordered window 5 words`, but you cannot use only `ordered` without also `window`. Oracle handles FTOrder the same way it handles Oracle Text operator `NEAR` with a `TRUE` value for option `ORDER`.

- FTUnaryNot (`ftnot`)

  FTUnaryNot must be used with FTAnd. You cannot use FTUnaryNot by itself. For example, you can use `ftand ftnot`, but you cannot use only `ftnot` without also `ftand`. Oracle handles FTUnaryNot the same way it handles Oracle Text operator `NOT`.

- FTWindow (`window`)

  Oracle handles FTWindow the same way it handles Oracle Text operator `NEAR`. You must specify the window size only in words, not in sentences or paragraphs (for example, `window 2 paragraphs`), and you must specify it as a numeric constant that is less than or equal to 100.

- FTWords

  FTWordsValue must be an XQuery literal string or a SQL bind variable whose value is passed to SQL function `XMLExists` or `XMLQuery` from a SQL expression whose evaluation returns a non-`XMLType` value.

  In addition, FTAnyallOption, if present, must be `any`. That is, FTWords must correspond to a sequence with only one item.

  Note: Even though FTWords corresponds to a sequence of only one item, you can still search for a phrase of multiple words, by using a single string for the entire phrase. So for example, although Oracle XML DB does not support using `{"found" "necklace"}` for FTWords, you can use `"found necklace"`.

Supported XQuery Full Text Match Options

Oracle XML DB supports *only* the following XQuery Full Text match options. Any applicable restrictions are noted. Use of the terms "must" and "must not" means that an error is raised if the specified restriction is not respected. Use of any match options not listed here raises an error.

- FTStemOption (`stemming`, `no stemming`)

The default behavior specified in the XQuery and XPath Full Text 1.0 Recommendation is used for each unsupported match option, with the following exceptions:

- FTLanguage (unsupported) – The language used is the language defined by the *default lexer*, which means the language that was used when the database was installed.

- FTStopWordOption (unsupported) – The stoplist used is the stoplist defined for that language.

See Also:

- *Oracle Text Reference* for information about the default lexer
- *Oracle Text Reference* for information about the stoplist used for each supported language

Unsupported XQuery Full Text Features

In addition to all FTSelection operators not mentioned in "Supported XQuery Full Text FTSelection Operators" on page 4-27 and all match options not mentioned in "Supported XQuery Full Text Match Options" on page 4-28, Oracle XML DB does *not* support the following XQuery Full Text features:

- FTIgnoreOption
- FTWeight (weight declarations, used with FTPrimaryWithOptions)
- FTScoreVar (score variables, used with XQuery ForClause and LetClause or with XPath 2.0 SimpleForClause)

XQuery Full Text Errors

A compile-time error is raised whenever you use an XQuery Full Text (XQFT) feature that Oracle does not support.

In addition, compile-time error ORA-18177 is raised whenever you use a supported XQFT expression in a SQL `WHERE` clause (typically in `XMLExists`), if you did not create a corresponding XML search index or if that index is not picked up.

See Also:

- "Unsupported XQuery Full Text Features" on page 4-29
- "Indexing XML Data for Full-Text Queries" on page 6-48 for information about creating an XML search index and handling error ORA-18177
- "Performance Tuning for XQuery" on page 5-39 for information about axes other than forward and descendent
- *Oracle Database SQL Language Reference* for information about SQL built-in data types

5

Query and Update of XML Data

This chapter describes operations for XML applications (both XML schema-based and non-schema-based). It includes some guidelines for querying and updating XML data.

This chapter contains these topics:

- Using XQuery with Oracle XML DB
- Querying XML Data Using SQL and PL/SQL
- SQL*Plus XQUERY Command
- Using XQuery with XQJ to Access Database Data
- Using XQuery with PL/SQL, JDBC, and ODP.NET to Access Database Data
- Updating XML Data
- Performance Tuning for XQuery

See Also:

- Chapter 3, "Overview of How To Use Oracle XML DB" for `XMLType` storage recommendations
- Chapter 17, "XML Schema Storage and Query: Basic" for how to work with XML schema-based `XMLType` tables and columns
- Chapter 4, "XQuery and Oracle XML DB" for information about updating XML data using XQuery Update

Using XQuery with Oracle XML DB

XQuery is a very general and expressive language, and SQL/XML functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast` combine that power of expression and computation with the strengths of SQL. This section illustrates some of what you can do with these SQL/XML functions.

You typically use XQuery with Oracle XML DB in the following ways. The examples here are organized to reflect these different uses.

- Query XML data in Oracle XML DB Repository.

  See "Querying XML Data in Oracle XML DB Repository Using XQuery".

- Query a relational table or view as if it were XML data. To do this, you use XQuery function `fn:collection`, passing as argument a URI that uses the URI-scheme name `oradb` together with the database location of the data.

  See "Querying Relational Data Using XQuery and URI Scheme oradb".

- Query `XMLType` data, possibly decomposing the resulting XML into relational data using function `XMLTable`.

  See "Querying XMLType Data Using XQuery".

Example 5–1 creates Oracle XML DB Repository resources that are used in some of the other examples in this chapter.

Example 5–1 Creating Resources for Examples

```
DECLARE
  res BOOLEAN;
  empsxmlstring VARCHAR2(300):=
    '<?xml version="1.0"?>
     <emps>
       <emp empno="1" deptno="10" ename="John" salary="21000"/>
       <emp empno="2" deptno="10" ename="Jack" salary="310000"/>
       <emp empno="3" deptno="20" ename="Jill" salary="100001"/>
     </emps>';
  empsxmlnsstring VARCHAR2(300):=
    '<?xml version="1.0"?>
     <emps xmlns="http://example.com">
       <emp empno="1" deptno="10" ename="John" salary="21000"/>
       <emp empno="2" deptno="10" ename="Jack" salary="310000"/>
       <emp empno="3" deptno="20" ename="Jill" salary="100001"/>
     </emps>';
  deptsxmlstring VARCHAR2(300):=
    '<?xml version="1.0"?>
     <depts>
       <dept deptno="10" dname="Administration"/>
       <dept deptno="20" dname="Marketing"/>
       <dept deptno="30" dname="Purchasing"/>
     </depts>';
BEGIN
  res := DBMS_XDB_REPOS.createResource('/public/emps.xml',   empsxmlstring);
  res := DBMS_XDB_REPOS.createResource('/public/empsns.xml', empsxmlnsstring);
  res := DBMS_XDB_REPOS.createResource('/public/depts.xml',  deptsxmlstring);
END;
/
```

XQuery Sequences Can Contain Data of Any XQuery Type

It is important to keep in mind that XQuery is a general *sequence*-manipulation language. Its expressions and their results are not necessarily XML data. An XQuery sequence can contain items of any XQuery type, which includes numbers, strings, Boolean values, dates, and various types of XML node (`document-node()`, `element()`, `attribute()`, `text()`, `namespace()`, and so on). Example 5–2 provides a sampling.

Example 5–2 XMLQuery Applied to a Sequence of Items of Different Types

```
SELECT XMLQuery('(1, 2 + 3, "a", 100 to 102, <A>33</A>)'
                RETURNING CONTENT) AS output
  FROM DUAL;

OUTPUT
--------------------------
1 5 a 100 101 102<A>33</A>

1 row selected.
```

Example 5–2 applies SQL/XML function XMLQuery to an XQuery sequence that contains items of several different kinds:

- an integer literal: 1
- a arithmetic expression: 2 + 3
- a string literal: "a"
- a sequence of integers: 100 to 102
- a constructed XML element node: <A>33</A>

Example 5–2 also shows construction of a sequence using the comma operator (,) and parentheses ((,)) for grouping.

The sequence expression 100 to 102 evaluates to the sequence (100, 101, 102), so the argument to XMLQuery here is a sequence that contains a nested sequence. The sequence argument is automatically flattened, as is always the case for XQuery sequences. The argument is, in effect, (1, 5, "a", 100, 101, 102, <A>33</A>).

Querying XML Data in Oracle XML DB Repository Using XQuery

This section presents examples of using XQuery with XML data in Oracle XML DB Repository. You use XQuery functions fn:doc and fn:collection to query file and folder resources in the repository, respectively. The examples in this section use XQuery function fn:doc to obtain a repository file that contains XML data, and then bind XQuery variables to parts of that data using for and let FLWOR-expression clauses.

> **See Also:** XQuery Functions fn:doc, fn:collection, and fn:doc-available

Example 5–3 queries two XML-document resources in Oracle XML DB Repository: /public/emps.xml and /public/depts.xml. It illustrates the use of fn:doc and each of the possible FLWOR-expression clauses.

Example 5–3 FLOWR Expression Using for, let, order by, where, and return

```
SELECT XMLQuery('for $e in doc("/public/emps.xml")/emps/emp
                 let $d :=
                   doc("/public/depts.xml")//dept[@deptno = $e/@deptno]/@dname
                 where $e/@salary > 100000
                 order by $e/@empno
                 return <emp ename="{$e/@ename}" dept="{$d}"/>'
                RETURNING CONTENT) FROM DUAL;

XMLQUERY('FOR$EINDOC("/PUBLIC/EMPS.XML")/EMPS/EMPLET$D:=DOC("/PUBLIC/DEPTS.XML")
--------------------------------------------------------------------------------
<emp ename="Jack" dept="Administration"></emp><emp ename="Jill" dept="Marketing"
></emp>

1 row selected.
```

In Example 5–3, the various FLWOR clauses perform these operations:

- **for** iterates over the emp elements in /public/emps.xml, binding variable $e to the value of each such element, in turn. That is, it iterates over a general list of employees, binding $e to each employee.

- **let** binds variable $d to a *sequence* consisting of all of the values of dname attributes of those dept elements in /public/emps.xml whose deptno attributes have the same value as the deptno attribute of element $e (this is a join operation). That is, it binds $d to the names of all of the departments that have the same department number as the department of employee $e. (It so happens that the dname value is unique for each deptno value in depts.xml.) Note that, unlike for, let never iterates over values; $d is bound only once in this example.
- Together, for and let produce a stream of tuples ($e, $d), where $e represents an employee and $d represents the names of all of the departments to which that employee belongs—in this case, the unique name of the employee's unique department.
- **where** filters this tuple stream, keeping only tuples with employees whose salary is greater than 100,000.
- **order by** sorts the filtered tuple stream by employee number, empno (in ascending order, by default).
- **return** constructs emp elements, one for each tuple. Attributes ename and dept of these elements are constructed using attribute ename from the input and $d, respectively. Note that the element and attribute names emp and ename in the output have no necessary connection with the same names in the input document emps.xml.

Example 5–4 also uses each of the FLWOR-expression clauses. It shows the use of XQuery functions doc, count, avg, and integer, which are in the namespace for built-in XQuery functions, http://www.w3.org/2003/11/xpath-functions. This namespace is bound to the prefix fn.

Example 5–4 FLOWR Expression Using Built-In Functions

```
SELECT XMLQuery('for $d in fn:doc("/public/depts.xml")/depts/dept/@deptno
                 let $e := fn:doc("/public/emps.xml")/emps/emp[@deptno = $d]
                 where fn:count($e) > 1
                 order by fn:avg($e/@salary) descending
                 return
                   <big-dept>{$d,
                              <headcount>{fn:count($e)}</headcount>,
                              <avgsal>{xs:integer(fn:avg($e/@salary))}</avgsal>}
                   </big-dept>'
               RETURNING CONTENT) FROM DUAL;

XMLQUERY('FOR$DINFN:DOC("/PUBLIC/DEPTS.XML")/DEPTS/DEPT/@DEPTNOLET$E:=FN:DOC("/P
--------------------------------------------------------------------------------
<big-dept deptno="10"><headcount>2</headcount><avgsal>165500</avgsal></big-dept>

1 row selected.
```

In Example 5–4, the various FLWOR clauses perform these operations:

- **for** iterates over deptno attributes in input document /public/depts.xml, binding variable $d to the value of each such attribute, in turn.
- **let** binds variable $e to a sequence consisting of all of the emp elements in input document /public/emps.xml whose deptno attributes have value $d (this is a join operation).
- Together, for and let produce a stream of tuples ($d, $e), where $d represents a department number and $e represents the set of employees in that department.
- **where** filters this tuple stream, keeping only tuples with more than one employee.

- **order by** sorts the filtered tuple stream by average salary in descending order. The average is computed by applying XQuery function `avg` (in namespace `fn`) to the values of attribute `salary`, which is attached to the `emp` elements of `$e`.
- **return** constructs `big-dept` elements, one for each tuple produced by `order by`. The `text()` node of `big-dept` contains the department number, bound to `$d`. A `headcount` child element contains the number of employees, bound to `$e`, as determined by XQuery function `count`. An `avgsal` child element contains the computed average salary.

Querying Relational Data Using XQuery and URI Scheme oradb

This section presents examples of using XQuery to query relational table or view data as if it were XML data. The examples use XQuery function `fn:collection`, passing as argument a URI that uses the URI-scheme name `oradb` together with the database location of the data.

Example 5–5 uses Oracle XQuery function `fn:collection` in a FLWOR expression to query two relational tables, `regions` and `countries`. Both tables belong to sample database schema `HR`. The example also passes scalar SQL value `Asia` to XQuery variable `$regionname`. Any SQL expression can be evaluated to produce a value passed to XQuery using `PASSING`. In this case, the value comes from a SQL*Plus variable, `REGION`. You must cast the value to the scalar SQL data type expected, in this case, `VARCHAR2(40)`.

Example 5–5 Querying Relational Data as XML Using XMLQuery

```
DEFINE REGION = 'Asia'
SELECT XMLQuery('for $i in fn:collection("oradb:/HR/REGIONS"),
                    $j in fn:collection("oradb:/HR/COUNTRIES")
                  where $i/ROW/REGION_ID = $j/ROW/REGION_ID
                    and $i/ROW/REGION_NAME = $regionname
                  return $j'
                PASSING CAST('&REGION' AS VARCHAR2(40)) AS "regionname"
                RETURNING CONTENT) AS asian_countries
  FROM DUAL;
```

This produces the following result. (The result is shown here pretty-printed, for clarity.)

```
ASIAN_COUNTRIES
----------------------------------------
<ROW>
  <COUNTRY_ID>AU</COUNTRY_ID>
  <COUNTRY_NAME>Australia</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>CN</COUNTRY_ID>
  <COUNTRY_NAME>China</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>HK</COUNTRY_ID>
  <COUNTRY_NAME>HongKong</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>IN</COUNTRY_ID>
  <COUNTRY_NAME>India</COUNTRY_NAME>
```

```
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>JP</COUNTRY_ID>
  <COUNTRY_NAME>Japan</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>SG</COUNTRY_ID>
  <COUNTRY_NAME>Singapore</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>

1 row selected.
```

In Example 5–5, the various FLWOR clauses perform these operations:

- **for** iterates over sequences of XML elements returned by calls to `fn:collection`. In the first call, each element corresponds to a row of relational table `hr.regions` and is bound to variable `$i`. Similarly, in the second call to `fn:collection`, `$j` is bound to successive rows of table `hr.countries`. Since `regions` and `countries` are not `XMLType` tables, the top-level element corresponding to a row in each table is `ROW` (a wrapper element). Iteration over the row elements is unordered.
- **where** filters the rows from both tables, keeping only those pairs of rows whose `region_id` is the same for each table (it performs a join on `region_id`) and whose `region_name` is `Asia`.
- **return** returns the filtered rows from table `hr.countries` as an XML document containing XML fragments with `ROW` as their top-level element.

Example 5–6 uses `fn:collection` within nested FLWOR expressions to query relational data.

Example 5–6 Querying Relational Data as XML Using a Nested FLWOR Expression

```
CONNECT hr
Enter password: password

Connected.

GRANT SELECT ON LOCATIONS TO OE
/
CONNECT oe
Enter password: password

Connected.

SELECT XMLQuery(
         'for $i in fn:collection("oradb:/OE/WAREHOUSES")/ROW
          return <Warehouse id="{$i/WAREHOUSE_ID}">
                   <Location>
                     {for $j in fn:collection("oradb:/HR/LOCATIONS")/ROW
                      where $j/LOCATION_ID eq $i/LOCATION_ID
                      return ($j/STREET_ADDRESS, $j/CITY, $j/STATE_PROVINCE)}
                   </Location>
                 </Warehouse>'
        RETURNING CONTENT) FROM DUAL;
```

This query is an example of using nested FLWOR expressions. It accesses relational table `warehouses`, which is in sample database schema `oe`, and relational table

locations, which is in sample database schema HR. To run this example as user oe, you must first connect as user hr and grant permission to user oe to perform SELECT operations on table locations.

This produces the following result. (The result is shown here pretty-printed, for clarity.)

```
XMLQUERY('FOR$IINFN:COLLECTION("ORADB:/OE/WAREHOUSES")/ROWRETURN<WAREHOUSEID="{$
--------------------------------------------------------------------------------
<Warehouse id="1">
  <Location>
    <STREET_ADDRESS>2014 Jabberwocky Rd</STREET_ADDRESS>
    <CITY>Southlake</CITY>
    <STATE_PROVINCE>Texas</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="2">
  <Location>
    <STREET_ADDRESS>2011 Interiors Blvd</STREET_ADDRESS>
    <CITY>South San Francisco</CITY>
    <STATE_PROVINCE>California</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="3">
  <Location>
    <STREET_ADDRESS>2007 Zagora St</STREET_ADDRESS>
    <CITY>South Brunswick</CITY>
    <STATE_PROVINCE>New Jersey</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="4">
  <Location>
    <STREET_ADDRESS>2004 Charade Rd</STREET_ADDRESS>
    <CITY>Seattle</CITY>
    <STATE_PROVINCE>Washington</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="5">
  <Location>
    <STREET_ADDRESS>147 Spadina Ave</STREET_ADDRESS>
    <CITY>Toronto</CITY>
    <STATE_PROVINCE>Ontario</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="6">
  <Location>
    <STREET_ADDRESS>12-98 Victoria Street</STREET_ADDRESS>
    <CITY>Sydney</CITY>
    <STATE_PROVINCE>New South Wales</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="7">
  <Location>
    <STREET_ADDRESS>Mariano Escobedo 9991</STREET_ADDRESS>
    <CITY>Mexico City</CITY>
    <STATE_PROVINCE>Distrito Federal,</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="8">
  <Location>
    <STREET_ADDRESS>40-5-12 Laogianggen</STREET_ADDRESS>
```

```
    <CITY>Beijing</CITY>
  </Location>
</Warehouse>
<Warehouse id="9">
  <Location>
    <STREET_ADDRESS>1298 Vileparle (E)</STREET_ADDRESS>
    <CITY>Bombay</CITY>
    <STATE_PROVINCE>Maharashtra</STATE_PROVINCE>
  </Location>
</Warehouse>

1 row selected.
```

In Example 5–6, the various FLWOR clauses perform these operations:

- The outer **for** iterates over the sequence of XML elements returned by `fn:collection`: each element corresponds to a row of relational table `oe.warehouses` and is bound to variable `$i`. Since `warehouses` is not an `XMLType` table, the top-level element corresponding to a row is `ROW`. The iteration over the row elements is unordered.
- The inner **for** iterates, similarly, over a sequence of XML elements returned by `fn:collection`: each element corresponds to a row of relational table `hr.locations` and is bound to variable `$j`.
- **where** filters the tuples (`$i`, `$j`), keeping only those whose `location_id` child is the same for `$i` and `$j` (it performs a join on `location_id`).
- The inner **return** constructs an XQuery sequence of elements `STREET_ADDRESS`, `CITY`, and `STATE_PROVINCE`, all of which are children of locations-table `ROW` element `$j`; that is, they are the values of the locations-table columns of the same name.
- The outer **return** wraps the result of the inner `return` in a `Location` element, and wraps that in a `Warehouse` element. It provides the `Warehouse` element with an `id` attribute whose value comes from the `warehouse_id` column of table `warehouses`.

> **See Also:** Example 5–41 on page 5-41 for the execution plan of Example 5–6

Example 5–7 uses SQL/XML function `XMLTable` to decompose the result of an XQuery query to produce virtual relational data. The XQuery expression used in this example is identical to the one used in Example 5–6; the result of evaluating the XQuery expression is a sequence of `Warehouse` elements. Function `XMLTable` produces a virtual relational table whose rows are those `Warehouse` elements. More precisely, in this example the value of pseudocolumn `COLUMN_VALUE` for each virtual-table row is an XML fragment (of type `XMLType`) with a single `Warehouse` element.

Example 5–7 Querying Relational Data as XML Using XMLTable

```
SELECT *
  FROM XMLTable(
         'for $i in fn:collection("oradb:/OE/WAREHOUSES")/ROW
          return <Warehouse id="{$i/WAREHOUSE_ID}">
                   <Location>
                     {for $j in fn:collection("oradb:/HR/LOCATIONS")/ROW
                      where $j/LOCATION_ID eq $i/LOCATION_ID
                      return ($j/STREET_ADDRESS, $j/CITY, $j/STATE_PROVINCE)}
                   </Location>
                 </Warehouse>');
```

This produces the same result as Example 5–6, except that each `Warehouse` element is output as a separate row, instead of all `Warehouse` elements being output together in a single row.

```
COLUMN_VALUE
------------------------------------------------------
<Warehouse id="1">
  <Location>
    <STREET_ADDRESS>2014 Jabberwocky Rd</STREET_ADDRESS>
    <CITY>Southlake</CITY>
    <STATE_PROVINCE>Texas</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="2">
  <Location>
    <STREET_ADDRESS>2011 Interiors Blvd</STREET_ADDRESS>
    <CITY>South San Francisco</CITY>
    <STATE_PROVINCE>California</STATE_PROVINCE>
  </Location>
</Warehouse>
. . .

9 rows selected.
```

> **See Also:** Example 5–42 on page 5-42 for the execution plan of Example 5–7

Querying XMLType Data Using XQuery

This section presents examples of using XQuery to query `XMLType` data.

The query in Example 5–8 passes an `XMLType` column, `warehouse_spec`, as *context* item to XQuery, using function `XMLQuery` with the `PASSING` clause. It constructs a `Details` element for each of the warehouses whose area is greater than 80,000: `/Warehouse/Area > 80000`.

Example 5–8 Querying an XMLType Column Using XMLQuery PASSING Clause

```
SELECT warehouse_name,
       XMLQuery(
         'for $i in /Warehouse
          where  $i/Area > 80000
          return <Details>
                   <Docks num="{$i/Docks}"/>
                   <Rail>{if ($i/RailAccess = "Y") then "true" else "false"}
                   </Rail>
                 </Details>'
        PASSING warehouse_spec RETURNING CONTENT) big_warehouses
  FROM oe.warehouses;
```

This produces the following output:

```
WAREHOUSE_NAME
--------------
BIG_WAREHOUSES
--------------
Southlake, Texas


San Francisco
```

```
New Jersey
<Details><Docks num=""></Docks><Rail>false</Rail></Details>

Seattle, Washington
<Details><Docks num="3"></Docks><Rail>true</Rail></Details>

Toronto


Sydney


Mexico City


Beijing


Bombay


9 rows selected.
```

In Example 5–8, function `XMLQuery` is applied to the `warehouse_spec` column in each row of table `warehouses`. The various FLWOR clauses perform these operations:

- **`for`** iterates over the `Warehouse` elements in each row of column `warehouse_spec` (the passed context item): each such element is bound to variable `$i`, in turn. The iteration is unordered.
- **`where`** filters the `Warehouse` elements, keeping only those whose `Area` child has a value greater than 80,000.
- **`return`** constructs an XQuery sequence of `Details` elements, each of which contains a `Docks` and a `Rail` child elements. The `num` attribute of the constructed `Docks` element is set to the `text()` value of the `Docks` child of `Warehouse`. The `text()` content of `Rail` is set to `true` or `false`, depending on the value of the `RailAccess` attribute of element `Warehouse`.

The `SELECT` statement in Example 5–8 applies to each row in table `warehouses`. The `XMLQuery` expression returns the *empty sequence* for those rows that do not match the XQuery expression. Only the warehouses in New Jersey and Seattle satisfy the XQuery query, so they are the only warehouses for which `<Details>...</Details>` is returned.

Example 5–9 uses SQL/XML function `XMLTable` to query an `XMLType` table, `oe.purchaseorder`, which contains XML Schema-based data. It uses the `PASSING` clause to provide the `purchaseorder` table as the context item for the XQuery-expression argument to `XMLTable`. Pseudocolumn `COLUMN_VALUE` of the resulting virtual table holds a constructed element, `A10po`, which contains the `Reference` information for those purchase orders whose `CostCenter` element has value `A10` and whose `User` element has value `SMCCAIN`. The query performs a join between the virtual table and database table `purchaseorder`.

Example 5–9 Using XMLTABLE with XML Schema-Based Data

```
SELECT xtab.COLUMN_VALUE
  FROM purchaseorder, XMLTable('for $i in /PurchaseOrder
                                where $i/CostCenter eq "A10"
```

```
                                    and $i/User eq "SMCCAIN"
                                  return <A10po pono="{$i/Reference}"/>'
                                PASSING OBJECT_VALUE) xtab;

COLUMN_VALUE
-------------------------------------------------
<A10po pono="SMCCAIN-20021009123336151PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336341PDT"></A10po>
<A10po pono="SMCCAIN-20021009123337173PDT"></A10po>
<A10po pono="SMCCAIN-20021009123335681PDT"></A10po>
<A10po pono="SMCCAIN-20021009123335470PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336972PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336842PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336512PDT"></A10po>
<A10po pono="SMCCAIN-20021009123333894PDT"></A10po>
<A10po pono="SMCCAIN-20021009123337403PDT"></A10po>

10 rows selected.
```

The `PASSING` clause of function `XMLTable` passes the `OBJECT_VALUE` of `XMLType` table `purchaseorder`, to serve as the XPath context. The `XMLTable` expression thus *depends* on the `purchaseorder` table. Because of this, table `purchaseorder` must appear *before* the `XMLTable` expression in the `FROM` list. This is a general requirement in any situation involving data dependence.

> **Note:** Whenever a `PASSING` clause refers to a column of an `XMLType` table in a query, that table ***must appear before*** the `XMLTable` expression in the query `FROM` list. This is because the `XMLTable` expression *depends* on the `XMLType` table—a *left lateral* (correlated) join is needed, to ensure a one-to-many (1:N) relationship between the `XMLType` table row accessed and the rows generated from it by `XMLTable`.

Example 5–10 is similar to Example 5–9 in its effect. It uses `XMLQuery`, instead of `XMLTable`, to query `oe.purchaseorder`. These two examples differ in their treatment of the empty sequences returned by the XQuery expression. In Example 5–9, these empty sequences are not joined with the `purchaseorder` table, so the overall SQL-query result set has only ten rows. In Example 5–10, these empty sequences are part of the overall result set of the SQL query, which contains 132 rows, one for each of the rows in table `purchaseorder`. All but ten of those rows are empty, and show up in the output as empty lines. To save space here, those empty lines have been removed.

Example 5–10 Using XMLQUERY with XML Schema-Based Data

```
SELECT XMLQuery('for $i in /PurchaseOrder
                 where $i/CostCenter eq "A10"
                   and $i/User eq "SMCCAIN"
                 return <A10po pono="{$i/Reference}"/>'
                PASSING OBJECT_VALUE
                RETURNING CONTENT)
  FROM purchaseorder;

XMLQUERY('FOR$IIN/PURCHASEORDERWHERE$I/COSTCENTEREQ"A10"AND$I/USEREQ"SMCCAIN"RET
--------------------------------------------------------------------------------
<A10po pono="SMCCAIN-20021009123336151PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336341PDT"></A10po>
<A10po pono="SMCCAIN-20021009123337173PDT"></A10po>
<A10po pono="SMCCAIN-20021009123335681PDT"></A10po>
```

```
<A10po pono="SMCCAIN-20021009123335470PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336972PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336842PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336512PDT"></A10po>
<A10po pono="SMCCAIN-2002100912333894PDT"></A10po>
<A10po pono="SMCCAIN-20021009123337403PDT"></A10po>

132 rows selected.
```

See Also: Example 5–43 on page 5-42 for the execution plan of Example 5–10

Example 5–11 uses `XMLTable` clauses `PASSING` and `COLUMNS`. The XQuery expression iterates over top-level `PurchaseOrder` elements, constructing a `PO` element for each purchase order with cost center `A10`. The resulting `PO` elements are then passed to `XMLTable` for processing.

Example 5–11 Using XMLTABLE with PASSING and COLUMNS Clauses

```
SELECT xtab.poref, xtab.priority, xtab.contact
  FROM purchaseorder,
       XMLTable('for $i in /PurchaseOrder
                 let $spl := $i/SpecialInstructions
                 where $i/CostCenter eq "A10"
                 return <PO>
                          <Ref>{$i/Reference}</Ref>
                          {if ($spl eq "Next Day Air" or $spl eq "Expedite") then
                             <Type>Fastest</Type>
                           else if ($spl eq "Air Mail") then
                             <Type>Fast</Type>
                           else ()}
                          <Name>{$i/Requestor}</Name>
                        </PO>'
                PASSING OBJECT_VALUE
                COLUMNS poref    VARCHAR2(20) PATH 'Ref',
                        priority VARCHAR2(8)  PATH 'Type' DEFAULT 'Regular',
                        contact  VARCHAR2(20) PATH 'Name') xtab;

POREF                PRIORITY CONTACT
-------------------- -------- --------------------
SKING-20021009123336 Fastest  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
SMCCAIN-200210091233 Fastest  Samuel B. McCain
JCHEN-20021009123337 Fastest  John Z. Chen
JCHEN-20021009123337 Regular  John Z. Chen
SKING-20021009123337 Regular  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
JCHEN-20021009123338 Regular  John Z. Chen
SMCCAIN-200210091233 Regular  Samuel B. McCain
SKING-20021009123335 Regular  Steven X. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
SKING-20021009123336 Regular  Steven A. King
SMCCAIN-200210091233 Fast     Samuel B. McCain
SKING-20021009123336 Fastest  Steven A. King
SKING-20021009123336 Fastest  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
JCHEN-20021009123335 Regular  John Z. Chen
SKING-20021009123336 Regular  Steven A. King
JCHEN-20021009123336 Regular  John Z. Chen
SKING-20021009123336 Regular  Steven A. King
```

```
SMCCAIN-200210091233 Regular  Samuel B. McCain
SKING-20021009123337 Regular  Steven A. King
SKING-20021009123338 Fastest  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
JCHEN-20021009123337 Regular  John Z. Chen
JCHEN-20021009123337 Regular  John Z. Chen
JCHEN-20021009123337 Regular  John Z. Chen
SKING-20021009123337 Regular  Steven A. King
JCHEN-20021009123337 Regular  John Z. Chen
SKING-20021009123337 Regular  Steven A. King
SKING-20021009123337 Regular  Steven A. King
SMCCAIN-200210091233 Fast     Samuel B. McCain

32 rows selected.
```

In Example 5–11, data from the children of `PurchaseOrder` is used to construct the children of `PO`, which are `Ref`, `Type`, and `Name`. The content of `Type` is taken from the content of `/PurchaseOrder/SpecialInstructions`, but the classes of `SpecialInstructions` are divided up differently for `Type`.

Function `XMLTable` breaks up the result of XQuery evaluation, returning it as three `VARCHAR2` columns of a virtual table: `poref`, `priority`, and `contact`. The `DEFAULT` clause is used to supply a default `priority` of `Regular`.

Example 5–11 does not use the clause `RETURNING SEQUENCE BY REF`, which means that the XQuery sequence returned and then used by the `COLUMNS` clause is passed by *value*, not by reference. That is, a copy of the targeted nodes is returned, not a reference to the actual nodes.

When the returned sequence is passed by value, the columns specified in a `COLUMNS` clause cannot refer to any data that is not in that returned copy. In particular, they cannot refer to data that *precedes* the targeted nodes in the source data.

To be able to refer to an arbitrary part of the source data from column specifications in a `COLUMNS` clause, you need to use the clause `RETURNING SEQUENCE BY REF`, which causes the sequence resulting from the XQuery expression to be returned by *reference*.

Example 5–12 shows the use of clause `RETURNING SEQUENCE BY REF`, which allows column `reference` to refer to a node that is outside the nodes targeted by the XQuery expression. Because the sequence of LineItem nodes is returned by reference, the code has access to the complete tree of nodes, so it can navigate upward and then back down to node `Reference`.

Example 5–12 Using XMLTABLE with RETURNING SEQUENCE BY REF

```
SELECT t.*
  FROM purchaseorder,
       XMLTable('/PurchaseOrder/LineItems/LineItem' PASSING OBJECT_VALUE
                RETURNING SEQUENCE BY REF
                COLUMNS reference   VARCHAR2(30) PATH '../../Reference',
                        item        VARCHAR2(4)  PATH '@ItemNumber',
                        description VARCHAR2(45) PATH 'Description') t
  WHERE item = 5;

REFERENCE                      ITEM DESCRIPTION
------------------------------ ---- -----------------------------------
AMCEWEN-20021009123336171PDT   5    Coup De Torchon (Clean Slate)
AMCEWEN-20021009123336271PDT   5    The Unbearable Lightness Of Being
PTUCKER-20021009123336191PDT   5    The Scarlet Empress
PTUCKER-20021009123336291PDT   5    The Unbearable Lightness Of Being
SBELL-20021009123336231PDT     5    Black Narcissus
```

```
SBELL-20021009123336331PDT     5    Fishing With John 1 -3
SKING-20021009123336321PDT     5    The Red Shoes
SMCCAIN-20021009123336151PDT   5    Wages of Fear
SMCCAIN-20021009123336341PDT   5    The Most Dangerous Game
VJONES-20021009123336301PDT    5    Le Trou

10 rows selected.
```

Clause `RETURNING SEQUENCE BY REF` lets you specify that the result of evaluating the top-level XQuery expression used to generate rows for `XMLTable` be returned by reference. The same kind of choice is available for the result of evaluating a `PATH` expression in a `COLUMNS` clause. To specify that such a result be returned by reference you use `XMLType (SEQUENCE) BY REF` as the column data type.

Example 5–13 illustrates this. It chains together two `XMLTable` tables, `t1` and `t2`, returning XML data from the source document by reference:

- For column `reference` of the top-level table, `t1`, because it corresponds to a node outside element `LineItem` (just as in Example 5–12)
- For column `part` of table `t1`, because it is passed to table `t2`, whose column `item` targets data outside node `Part`

Example 5–13 Using Chained XMLTABLE with Access by Reference

```
SELECT t1.reference, t2.id, t2.item
  FROM purchaseorder,
       XMLTable('/PurchaseOrder/LineItems' PASSING OBJECT_VALUE
                RETURNING SEQUENCE BY REF
                COLUMNS part XMLType (SEQUENCE) BY REF PATH 'LineItem/Part',
                        reference VARCHAR2(30)         PATH '../Reference') t1,
       XMLTable('.' PASSING t1.part
                RETURNING SEQUENCE BY REF
                COLUMNS id   VARCHAR2(12) PATH '@Id',
                        item NUMBER       PATH '../@ItemNumber') t2;
```

In table `t1`, the type used for column `part` is `XMLType (SEQUENCE) BY REF`, so that the `part` data is a reference to the source data targeted by its `PATH` expression, `LineItem/Part`. This is needed because the `PATH` expression for column `item` in table `t2` targets attribute `ItemNumber` of the parent of element `Part`, `LineItem`. Without specifying that `part` is a reference, it would be a copy of just the `Part` element, so that using `PATH` expression `../@ItemNumber` would raise an error.

Example 5–14 uses SQL/XML function `XMLTable` to break up the XML data in an `XMLType` collection element, `LineItem`, into separate columns of a virtual table.

Example 5–14 Using XMLTABLE to Decompose XML Collection Elements into Relational Data

```
SELECT lines.lineitem, lines.description, lines.partid,
       lines.unitprice, lines.quantity
  FROM purchaseorder,
       XMLTable('for $i in /PurchaseOrder/LineItems/LineItem
                 where $i/@ItemNumber >= 8
                  and $i/Part/@UnitPrice > 50
                  and $i/Part/@Quantity > 2
                 return $i'
                PASSING OBJECT_VALUE
                COLUMNS lineitem    NUMBER       PATH '@ItemNumber',
                        description VARCHAR2(30) PATH 'Description',
                        partid      NUMBER       PATH 'Part/@Id',
```

```
                        unitprice   NUMBER       PATH 'Part/@UnitPrice',
                        quantity    NUMBER       PATH 'Part/@Quantity') lines;

LINEITEM DESCRIPTION                         PARTID UNITPRICE QUANTITY
-------- ------------------------------ ------------- --------- --------
      11 Orphic Trilogy                  37429148327        80        3
      22 Dreyer Box Set                  37429158425        80        4
      11 Dreyer Box Set                  37429158425        80        3
      16 Dreyer Box Set                  37429158425        80        3
       8 Dreyer Box Set                  37429158425        80        3
      12 Brazil                          37429138526        60        3
      18 Eisenstein: The Sound Years     37429149126        80        4
      24 Dreyer Box Set                  37429158425        80        3
      14 Dreyer Box Set                  37429158425        80        4
      10 Brazil                          37429138526        60        3
      17 Eisenstein: The Sound Years     37429149126        80        3
      16 Orphic Trilogy                  37429148327        80        4
      13 Orphic Trilogy                  37429148327        80        4
      10 Brazil                          37429138526        60        4
      12 Eisenstein: The Sound Years     37429149126        80        3
      12 Dreyer Box Set                  37429158425        80        4
      13 Dreyer Box Set                  37429158425        80        4

17 rows selected.
```

See Also:

- Example 5–44 on page 5-43 for the execution plan of Example 5–14
- "Creating a Relational View over XML: Mapping XML Nodes to Columns" on page 9-2, for an example of applying `XMLTable` to multiple document levels (multilevel chaining)

Using Namespaces with XQuery

You can use the XQuery `declare namespace` declaration in the prolog of an XQuery expression to define a namespace prefix. You can use `declare` **`default`** `namespace` to establish the namespace as the default namespace for the expression.

Be aware of the following pitfall, if you use SQL*Plus: If the semicolon (`;`) at the end of a namespace declaration terminates a line, SQL*Plus interprets it as a SQL terminator. To avoid this, you can do one of the following:

- Place the text that follows the semicolon on the same line.
- Place a comment, such as **`(: :)`**, after the semicolon, on the same line.
- Turn off the recognition of the SQL terminator with SQL*Plus command `SET SQLTERMINATOR`.

Example 5–15 illustrates use of a namespace declaration in an XQuery expression.

Example 5–15 Using XMLQUERY with a Namespace Declaration

```
SELECT XMLQuery('declare namespace e = "http://example.com";
ERROR:
ORA-01756: quoted string not properly terminated

                for $i in doc("/public/empsns.xml")/e:emps/e:emp
SP2-0734: unknown command beginning "for $i in ..." - rest of line ignored.
...
```

```
-- This works - do not end the line with ";".
SELECT XMLQuery('declare namespace e = "http://example.com"; for
                    $i in doc("/public/empsns.xml")/e:emps/e:emp
                 let $d :=
                   doc("/public/depts.xml")//dept[@deptno=$i/@deptno]/@dname
                 where $i/@salary > 100000
                 order by $i/@empno
                 return <emp ename="{$i/@ename}" dept="{$d}"/>'
                RETURNING CONTENT) FROM DUAL;

XMLQUERY('DECLARENAMESPACEE="HTTP://EXAMPLE.COM";FOR$IINDOC("/PUBLIC/EMPSNS.XML"
--------------------------------------------------------------------------------
<emp ename="Jack" dept=""></emp><emp ename="Jill" dept=""></emp>

-- This works too - add a comment after the ";".
SELECT XMLQuery('declare namespace e = "http://example.com";  (: :)
                 for $i in doc("/public/empsns.xml")/e:emps/e:emp
                 let $d := doc("/public/depts.xml")//dept[@deptno=$i/@deptno]/@dname
                 where $i/@salary > 100000
                 order by $i/@empno
                 return <emp ename="{$i/@ename}" dept="{$d}"/>'
                RETURNING CONTENT) FROM DUAL;

XMLQUERY('DECLARENAMESPACEE="HTTP://EXAMPLE.COM";(::)FOR$IINDOC("/PUBLIC/EMPSNS.
--------------------------------------------------------------------------------
<emp ename="Jack" dept=""></emp><emp ename="Jill" dept=""></emp>

1 row selected.

-- This works too - tell SQL*Plus to ignore the ";".

SET SQLTERMINATOR OFF

SELECT XMLQuery('declare namespace e = "http://example.com";
                 for $i in doc("/public/empsns.xml")/e:emps/e:emp
                 let $d :=
                   doc("/public/depts.xml")//dept[@deptno=$i/@deptno]/@dname
                 where $i/@salary > 100000
                 order by $i/@empno
                 return <emp ename="{$i/@ename}" dept="{$d}"/>'
                RETURNING CONTENT) FROM DUAL
/

XMLQUERY('DECLARENAMESPACEE="HTTP://EXAMPLE.COM";FOR$IINDOC("/PUBLIC/EMPSNS.XML"
--------------------------------------------------------------------------------
<emp ename="Jack" dept=""></emp><emp ename="Jill" dept=""></emp>
```

An XQuery namespace declaration has no effect outside of its XQuery expression. To declare a namespace prefix for use in an `XMLTable` expression outside of the XQuery expression, use the `XMLNAMESPACES` clause. This clause also covers the XQuery expression argument to `XMLTable`, eliminating the need for a separate declaration in the XQuery prolog.

In Example 5–16, `XMLNAMESPACES` is used to define the prefix `e` for the namespace `http://example.com`. This namespace is used in the `COLUMNS` clause and the XQuery expression of the `XMLTable` expression.

Example 5–16 Using XMLTABLE with the XMLNAMESPACES Clause

```
SELECT * FROM XMLTable(XMLNAMESPACES ('http://example.com' AS "e"),
```

```
                    'for $i in doc("/public/empsns.xml")
                     return $i/e:emps/e:emp'
                    COLUMNS name VARCHAR2(6) PATH '@ename',
                            id   NUMBER      PATH '@empno');
```

This produces the following result:

```
NAME           ID
------ ----------
John            1
Jack            2
Jill            3

3 rows selected.
```

It is the presence of qualified names `e:ename` and `e:empno` in the `COLUMNS` clause that necessitates using the `XMLNAMESPACES` clause. Otherwise, a prolog namespace declaration (`declare namespace e = "http://example.com"`) would suffice for the XQuery expression itself.

Because the same namespace is used throughout the `XMLTable` expression, a default namespace could be used: `XMLNAMESPACES (DEFAULT 'http://example.com')`. The qualified name `$i/e:emps/e:emp` could then be written without an explicit prefix: `$i/emps/emp`.

Querying XML Data Using SQL and PL/SQL

You can query XML data from `XMLType` columns and tables in the following ways:

- Select `XMLType` data using SQL, PL/SQL, or Java.
- Query `XMLType` data using SQL/XML functions such as `XMLQuery`. See "Querying XMLType Data Using XQuery" on page 5-9.
- Perform full-text search using XQuery Full Text or Oracle Text operators. See "Support for XQuery Full Text" on page 4-27, Chapter 6, "Indexes for XMLType Data" and Appendix E, "Full-Text Search over XML Data Without XQuery".

The examples in this section illustrate different ways you can use SQL and PL/SQL to query XML data. Example 5–17 inserts two rows into table `purchaseorder`, then queries data in those rows using SQL/XML functions `XMLCast`, `XMLQuery`, and `XMLExists`.

Example 5–17 Querying XMLTYPE Data

```
INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'SMCCAIN-2002091213000000PDT.xml'),
                  nls_charset_id('AL32UTF8')));

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'VJONES-20020916140000000PDT.xml'),
                  nls_charset_id('AL32UTF8')));

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) reference,
       XMLCast(XMLQuery('$p/PurchaseOrder/*//User'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) userid,
       CASE
         WHEN XMLExists('$p/PurchaseOrder/Reject/Date'
```

```
                        PASSING po.OBJECT_VALUE AS "p")
           THEN 'Rejected'
           ELSE 'Accepted'
       END "STATUS",
       XMLCast(XMLQuery('$p//Date'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(12)) status_date
  FROM purchaseorder po
  WHERE XMLExists('$p//Date' PASSING po.OBJECT_VALUE AS "p")
  ORDER BY XMLCast(XMLQuery('$p//Date' PASSING po.OBJECT_VALUE AS "p"
                                       RETURNING CONTENT)
                   AS VARCHAR2(12));

REFERENCE                       USERID   STATUS   STATUS_DATE
------------------------------- -------- -------- ------------
VJONES-20020916140000000PDT     SVOLLMAN Accepted 2002-10-11
SMCCAIN-2002091213000000PDT     SKING    Rejected 2002-10-12

2 rows selected.
```

Example 5–18 uses a PL/SQL cursor to query XML data. It uses a local `XMLType` instance to store transient data.

Example 5–18 Querying Transient XMLTYPE Data Using a PL/SQL Cursor

```
DECLARE
  xNode      XMLType;
  vText      VARCHAR2(256);
  vReference VARCHAR2(32);
  CURSOR getPurchaseOrder(reference IN VARCHAR2) IS
           SELECT OBJECT_VALUE XML
             FROM purchaseorder
             WHERE XMLExists('$p/PurchaseOrder[Reference=$r]'
                             PASSING OBJECT_VALUE AS "p",
                                     reference    AS "r");
BEGIN
  vReference := 'EABEL-20021009123335791PDT';
  FOR c IN getPurchaseOrder(vReference) LOOP
    xNode := c.XML.extract('//Requestor');
    SELECT XMLSerialize(CONTENT
                        XMLQuery('//text()' PASSING xNode RETURNING CONTENT))
           INTO vText FROM DUAL;
    DBMS_OUTPUT.put_line('The Requestor for Reference '
                         || vReference || ' is '|| vText);
  END LOOP;
  vReference := 'PTUCKER-20021009123335430PDT';
  FOR c IN getPurchaseOrder(vReference) LOOP
    xNode := c.XML.extract('//LineItem[@ItemNumber="1"]/Description');
    SELECT XMLSerialize(CONTENT
                        XMLQuery('//text()' PASSING xNode RETURNING CONTENT))
           INTO vText FROM DUAL;
    DBMS_OUTPUT.put_line('The Description of LineItem[1] for Reference '
                         || vReference || ' is '|| vText);
  END LOOP;
END;
/
The Requestor for Reference EABEL-20021009123335791PDT is Ellen S. Abel
The Description of LineItem[1] for Reference PTUCKER-20021009123335430PDT is
 Picnic at
Hanging Rock
```

```
PL/SQL procedure successfully completed.
```

Example 5–19 and Example 5–20 both use SQL/XML function `XMLTable` to extract data from an XML purchase-order document. They then insert that data into a relational table. Example 5–19 uses SQL; Example 5–20 uses PL/SQL.

Example 5–19 Extracting XML Data and Inserting It into a Relational Table Using SQL

```
CREATE TABLE purchaseorder_table (reference           VARCHAR2(28) PRIMARY KEY,
                                  requestor           VARCHAR2(48),
                                  actions             XMLType,
                                  userid              VARCHAR2(32),
                                  costcenter          VARCHAR2(3),
                                  shiptoname          VARCHAR2(48),
                                  address             VARCHAR2(512),
                                  phone               VARCHAR2(32),
                                  rejectedby          VARCHAR2(32),
                                  daterejected        DATE,
                                  comments            VARCHAR2(2048),
                                  specialinstructions VARCHAR2(2048));

CREATE TABLE purchaseorder_lineitem (reference,
                                     FOREIGN KEY ("REFERENCE")
                                       REFERENCES "PURCHASEORDER_TABLE" ("REFERENCE") ON DELETE CASCADE,
                                     lineno      NUMBER(10), PRIMARY KEY ("REFERENCE", "LINENO"),
                                     upc         VARCHAR2(14),
                                     description VARCHAR2(128),
                                     quantity    NUMBER(10),
                                     unitprice   NUMBER(12,2));

INSERT INTO purchaseorder_table (reference, requestor, actions, userid, costcenter, shiptoname, address,
                                 phone, rejectedby, daterejected, comments, specialinstructions)
  SELECT t.reference, t.requestor, t.actions, t.userid, t.costcenter, t.shiptoname, t.address,
         t.phone, t.rejectedby, t.daterejected, t.comments, t.specialinstructions
    FROM purchaseorder p,
         XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                  COLUMNS reference           VARCHAR2(28)   PATH 'Reference',
                          requestor           VARCHAR2(48)   PATH 'Requestor',
                          actions             XMLType        PATH 'Actions',
                          userid              VARCHAR2(32)   PATH 'User',
                          costcenter          VARCHAR2(3)    PATH 'CostCenter',
                          shiptoname          VARCHAR2(48)   PATH 'ShippingInstructions/name',
                          address             VARCHAR2(512)  PATH 'ShippingInstructions/address',
                          phone               VARCHAR2(32)   PATH 'ShippingInstructions/telephone',
                          rejectedby          VARCHAR2(32)   PATH 'Reject/User',
                          daterejected        DATE           PATH 'Reject/Date',
                          comments            VARCHAR2(2048) PATH 'Reject/Comments',
                          specialinstructions VARCHAR2(2048) PATH 'SpecialInstructions') t
    WHERE t.reference = 'EABEL-20021009123336251PDT';

INSERT INTO purchaseorder_lineitem (reference, lineno, upc, description, quantity, unitprice)
  SELECT t.reference, li.lineno, li.upc, li.description, li.quantity, li.unitprice
    FROM purchaseorder p,
         XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                  COLUMNS reference VARCHAR2(28) PATH 'Reference',
                          lineitem XMLType PATH 'LineItems/LineItem') t,
         XMLTable('LineItem' PASSING t.lineitem
                  COLUMNS lineno      NUMBER(10)    PATH '@ItemNumber',
                          upc         VARCHAR2(14)  PATH 'Part/@Id',
                          description VARCHAR2(128) PATH 'Description',
                          quantity    NUMBER(10)    PATH 'Part/@Quantity',
                          unitprice   NUMBER(12,2)  PATH 'Part/@UnitPrice') li
    WHERE t.reference = 'EABEL-20021009123336251PDT';
```

```
SELECT reference, userid, shiptoname, specialinstructions FROM purchaseorder_table;

REFERENCE                       USERID   SHIPTONAME                                      SPECIALINSTRUCTIONS
------------------------------- -------- ----------------------------------------------- -------------------
EABEL-20021009123336251PDT      EABEL    Ellen S. Abel                                   Counter to Counter

SELECT reference, lineno, upc, description, quantity FROM purchaseorder_lineitem;

REFERENCE                          LINENO UPC           DESCRIPTION                       QUANTITY
------------------------------- ---------- ------------- --------------------------------- ----------
EABEL-20021009123336251PDT              1 37429125526   Samurai 2: Duel at Ichijoji Temple          3
EABEL-20021009123336251PDT              2 37429128220   The Red Shoes                               4
EABEL-20021009123336251PDT              3 715515009058  A Night to Remember                         1
```

Example 5–20 defines and uses a PL/SQL procedure to extract data from an XML purchase-order document and insert it into a relational table.

Example 5–20 Extracting XML Data and Inserting It into a Table Using PL/SQL

```
CREATE OR REPLACE PROCEDURE insertPurchaseOrder(purchaseorder XMLType) AS reference VARCHAR2(28);
BEGIN
  INSERT INTO purchaseorder_table (reference, requestor, actions, userid, costcenter, shiptoname, address,
                                   phone, rejectedby, daterejected, comments, specialinstructions)
    SELECT * FROM XMLTable('$p/PurchaseOrder' PASSING purchaseorder AS "p"
                           COLUMNS reference           VARCHAR2(28)   PATH 'Reference',
                                   requestor           VARCHAR2(48)   PATH 'Requestor',
                                   actions             XMLType        PATH 'Actions',
                                   userid              VARCHAR2(32)   PATH 'User',
                                   costcenter          VARCHAR2(3)    PATH 'CostCenter',
                                   shiptoname          VARCHAR2(48)   PATH 'ShippingInstructions/name',
                                   address             VARCHAR2(512)  PATH 'ShippingInstructions/address',
                                   phone               VARCHAR2(32)   PATH 'ShippingInstructions/telephone',
                                   rejectedby          VARCHAR2(32)   PATH 'Reject/User',
                                   daterejected        DATE           PATH 'Reject/Date',
                                   comments            VARCHAR2(2048) PATH 'Reject/Comments',
                                   specialinstructions VARCHAR2(2048) PATH 'SpecialInstructions');

  INSERT INTO purchaseorder_lineitem (reference, lineno, upc, description, quantity, unitprice)
    SELECT t.reference, li.lineno, li.upc, li.description, li.quantity, li.unitprice
    FROM XMLTable('$p/PurchaseOrder' PASSING purchaseorder AS "p"
                  COLUMNS reference VARCHAR2(28) PATH 'Reference',
                          lineitem XMLType PATH 'LineItems/LineItem') t,
         XMLTable('LineItem' PASSING t.lineitem
                  COLUMNS lineno NUMBER(10)    PATH '@ItemNumber',
                          upc VARCHAR2(14)  PATH 'Part/@Id',
                          description VARCHAR2(128) PATH 'Description',
                          quantity NUMBER(10)    PATH 'Part/@Quantity',
                          unitprice NUMBER(12,2)  PATH 'Part/@UnitPrice') li;
END;
CALL insertPurchaseOrder(XMLType(bfilename('XMLDIR', 'purchaseOrder.xml'), nls_charset_id('AL32UTF8')));

SELECT reference, userid, shiptoname, specialinstructions FROM purchaseorder_table;

REFERENCE                       USERID   SHIPTONAME                                      SPECIALINSTRUCTIONS
------------------------------- -------- ----------------------------------------------- -------------------
SBELL-20021009123336 01PDT      SBELL    Sarah J. Bell                                   Air Mail


SELECT reference, lineno, upc, description, quantity FROM purchaseorder_lineitem;

REFERENCE                 LINENO UPC          DESCRIPTION                       QUANTITY
------------------------- ------ ------------ --------------------------------- --------
SBELL-20021009123336 01PDT      1 715515009058 A Night to Remember                       2
SBELL-20021009123336 01PDT      2 37429140222  The Unbearable Lightness Of Being         2
SBELL-20021009123336 01PDT      3 715515011020 Sisters                                   4
```

Example 5–21 tabulates the purchase orders whose shipping address contains the string "Shores" and which were requested by customers whose names contain the string "ll" (double L). These purchase orders are grouped by customer and counted. The example uses XQuery Full Text to perform full-text search.

Example 5–21 Searching XML Data Using SQL/XML Functions

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                 AS VARCHAR2(128)) name,
       count(*)
  FROM purchaseorder po
  WHERE
    XMLExists(
      'declare namespace ora="http://xmlns.oracle.com/xdb"; (: :)
       $p/PurchaseOrder/ShippingInstructions[address/text() contains text "Shores"]'
      PASSING po.OBJECT_VALUE AS "p")
    AND XMLCast(XMLQuery('$p/PurchaseOrder/Requestor/text()'
                         PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                  AS VARCHAR2(128))
        LIKE '%ll%'
  GROUP BY XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                            PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                   AS VARCHAR2(128));

NAME                   COUNT(*)
-------------------- ----------
Allan D. McEwen               9
Ellen S. Abel                 4
Sarah J. Bell                13
William M. Smith              7
```

Example 5–22 extracts the fragments of a document that are identified by an XPath expression. The XMLType instance returned by XMLQuery can be a set of nodes, a singleton node, or a text value. Example 5–22 uses XMLType method isFragment() to determine whether the result is a fragment.

Example 5–22 Extracting Fragments Using XMLQUERY

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING po.OBJECT_VALUE AS "p"
                                                    RETURNING CONTENT)
               AS VARCHAR2(30)) reference,
       count(*)
  FROM purchaseorder po, XMLTable('$p//LineItem[Part/@Id="37429148327"]' PASSING OBJECT_VALUE AS "p")
  WHERE XMLQuery('$p/PurchaseOrder/LineItems/LineItem[Part/@Id="37429148327"]'
                 PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT).isFragment() = 1
  GROUP BY XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                   AS VARCHAR2(30))
  ORDER BY XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                   AS VARCHAR2(30));

REFERENCE                      COUNT(*)
------------------------------ ----------
TFOX-20021009123337784PDT               3
```

Note: You cannot insert fragments into XMLType columns. You can use SQL/XML function XMLQuery to convert a fragment into a well-formed document.

SQL*Plus XQUERY Command

Example 5–23 shows how you can enter an XQuery expression directly at the SQL*Plus command line, by preceding the expression with the SQL*Plus command **XQUERY** and following it with a slash (/) on a line by itself. Oracle Database treats XQuery expressions submitted with this command the same way it treats XQuery expressions in SQL/XML functions XMLQuery and XMLTable. Execution is identical, with the same optimizations.

Example 5–23 Using the SQL*Plus XQUERY Command

```
SQL> XQUERY for $i in fn:collection("oradb:/HR/DEPARTMENTS")
  2  where $i/ROW/DEPARTMENT_ID < 50
  3  return $i
  4  /

Result Sequence
--------------------------------------------------------------------------------
<ROW><DEPARTMENT_ID>10</DEPARTMENT_ID><DEPARTMENT_NAME>Administration</DEPARTMEN
T_NAME><MANAGER_ID>200</MANAGER_ID><LOCATION_ID>1700</LOCATION_ID></ROW>

<ROW><DEPARTMENT_ID>20</DEPARTMENT_ID><DEPARTMENT_NAME>Marketing</DEPARTMENT_NAM
E><MANAGER_ID>201</MANAGER_ID><LOCATION_ID>1800</LOCATION_ID></ROW>

<ROW><DEPARTMENT_ID>30</DEPARTMENT_ID><DEPARTMENT_NAME>Purchasing</DEPARTMENT_NA
ME><MANAGER_ID>114</MANAGER_ID><LOCATION_ID>1700</LOCATION_ID></ROW>

<ROW><DEPARTMENT_ID>40</DEPARTMENT_ID><DEPARTMENT_NAME>Human Resources</DEPARTME
NT_NAME><MANAGER_ID>203</MANAGER_ID><LOCATION_ID>2400</LOCATION_ID></ROW>
```

There are also a few SQL*Plus SET commands that you can use for settings that are specific to XQuery. Use SHOW XQUERY to see the current settings.

- **SET XQUERY BASEURI** – Set the base URI for XQUERY. URIs in XQuery expressions are relative to this URI.
- **SET XQUERY CONTEXT** – Specify a context item for subsequent XQUERY evaluations.

See Also: *SQL*Plus User's Guide and Reference*

Using XQuery with XQJ to Access Database Data

XQuery API for Java (XQJ), also known as JSR-225, provides an industry-standard way for Java programs to access XML data using XQuery. It lets you evaluate XQuery expressions against XML data sources and process the results as XML data.

Oracle provides two XQuery engines for evaluating XQuery expressions: one in Oracle XML DB, for use with XML data in the database, and one in Oracle XML Developer's Kit, for use with XML data outside the database.

Similarly, Oracle provides two mid-tier XQJ implementations for accessing these two XQuery engines. Both implementations are part of Oracle XML Developer's Kit (XDK). You use XDK to access XML data with XQJ, regardless of whether that data resides in the database or elsewhere.

In particular, you can use XDK and XQJ to access XML data in Oracle XML DB. A typical use case for this feature is to access data stored in remote databases from a local Java program.

See Also:

- XQuery API for Java (XQJ) 1.0 Specification, March 2009, http://jcp.org/aboutJava/communityprocess/final/jsr225/

  This specification is quite concrete and helpful, with understandable examples.
- *Oracle XML Developer's Kit Programmer's Guide* for complete information about using XQJ with Oracle XML Developer's Kit
- *Oracle XML Developer's Kit Programmer's Guide* for information, including examples, about using XQJ with XDK to access XML data in the database

Using XQuery with PL/SQL, JDBC, and ODP.NET to Access Database Data

This section provides examples of using XQuery with the Oracle APIs for PL/SQL, JDBC, and Oracle Data Provider for .NET (ODP.NET).

Example 5–24 shows how to use XQuery with PL/SQL, in particular, how to bind *dynamic variables* to an XQuery expression using the `XMLQuery PASSING` clause. The bind variables `:1` and `:2` are bound to the PL/SQL bind arguments `nbitems` and `partid`, respectively. These are then passed to XQuery as XQuery variables `itemno` and `id`, respectively.

Example 5–24 Using XQuery with PL/SQL

```
DECLARE
  sql_stmt VARCHAR2(2000); -- Dynamic SQL statement to execute
  nbitems  NUMBER := 3; -- Number of items
  partid   VARCHAR2(20):= '715515009058'; -- Part ID
  result   XMLType;
  doc      DBMS_XMLDOM.DOMDocument;
  ndoc     DBMS_XMLDOM.DOMNode;
  buf      VARCHAR2(20000);
BEGIN
  sql_stmt :=
    'SELECT XMLQuery(
               ''for $i in fn:collection("oradb:/OE/PURCHASEORDER") ' ||
                'where count($i/PurchaseOrder/LineItems/LineItem) = $itemno ' ||
                  'and $i/PurchaseOrder/LineItems/LineItem/Part/@Id = $id ' ||
                'return $i/PurchaseOrder/LineItems'' ' ||
               'PASSING :1 AS "itemno", :2 AS "id" ' ||
               'RETURNING CONTENT) FROM DUAL';

  EXECUTE IMMEDIATE sql_stmt INTO result USING nbitems, partid;
  doc  := DBMS_XMLDOM.newDOMDocument(result);
  ndoc := DBMS_XMLDOM.makeNode(doc);
  DBMS_XMLDOM.writeToBuffer(ndoc, buf);
  DBMS_OUTPUT.put_line(buf);
END;
/
```

This produces the following output:

```
<LineItems>
  <LineItem ItemNumber="1">
    <Description>Samurai 2: Duel at Ichijoji Temple</Description>
    <Part Id="37429125526" UnitPrice="29.95" Quantity="3"/>
  </LineItem>
```

```
    <LineItem ItemNumber="2">
      <Description>The Red Shoes</Description>
      <Part Id="37429128220" UnitPrice="39.95" Quantity="4"/>
    </LineItem>
    <LineItem ItemNumber="3">
      <Description>A Night to Remember</Description>
      <Part Id="715515009058" UnitPrice="39.95" Quantity="1"/>
    </LineItem>
  </LineItems>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>A Night to Remember</Description>
      <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="2">
      <Description>The Unbearable Lightness Of Being</Description>
      <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="3">
      <Description>Sisters</Description>
      <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
    </LineItem>
  </LineItems>

PL/SQL procedure successfully completed.
```

Example 5–25 shows how to use XQuery with JDBC, binding variables by position with the `PASSING` clause of SQL/XML function `XMLTable`.

Example 5–25 Using XQuery with JDBC

```
import java.sql.*;
import oracle.sql.*;
import oracle.jdbc.*;
import oracle.xdb.XMLType;
import java.util.*;

public class QueryBindByPos
{
  public static void main(String[] args) throws Exception, SQLException
  {
    System.out.println("*** JDBC Access of XQuery using Bind Variables ***");
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());
    OracleConnection conn
      = (OracleConnection)
        DriverManager.getConnection("jdbc:oracle:oci8:@localhost:1521:ora11gR1", "oe", "oe");
    String xqString
      = "SELECT COLUMN_VALUE" +
          "FROM XMLTable('for $i in fn:collection(\"oradb:/OE/PURCHASEORDER\") " +
                        "where $i/PurchaseOrder/Reference= $ref " +
                        "return $i/PurchaseOrder/LineItems' " +
                       "PASSING ? AS \"ref\")";
    OraclePreparedStatement stmt = (OraclePreparedStatement)conn.prepareStatement(xqString);
    String refString = "EABEL-20021009123336251PDT"; // Set the filter value
    stmt.setString(1, refString); // Bind the string
    ResultSet rs = stmt.executeQuery();
    while (rs.next())
    {
       XMLType desc = (XMLType) rs.getObject(1);
       System.out.println("LineItem Description: " + desc.getStringVal());
```

```
       desc.close();
    }
    rs.close();
    stmt.close();
  }
}
```

This produces the following output:

```
*** JDBC Access of Database XQuery with Bind Variables ***
LineItem Description: Samurai 2: Duel at Ichijoji Temple
LineItem Description: The Red Shoes
LineItem Description: A Night to Remember
```

Example 5–26 shows how to use XQuery with ODP.NET and the C# language. The C# input parameters `:nbitems` and `:partid` are passed to XQuery as XQuery variables `itemno` and `id`, respectively.

Example 5–26 Using XQuery with ODP.NET and C#

```
using System;
using System.Data;
using System.Text;
using System.IO;
using System.Xml;
using Oracle.DataAccess.Client;
using Oracle.DataAccess.Types;

namespace XQuery
{
  /// <summary>
  /// Demonstrates how to bind variables for XQuery calls
  /// </summary>
  class XQuery
  {
    /// <summary>
    /// The main entry point for the application.
    /// </summary>
    static void Main(string[] args)
    {
      int rows = 0;
      StreamReader sr = null;

      // Create the connection.
      string constr = "User Id=oe;Password=***********;Data Source=ora11gr2"; // Replace with real password.
      OracleConnection con = new OracleConnection(constr);
      con.Open();

      // Create the command.
      OracleCommand cmd = new OracleCommand("", con);

      // Set the XML command type to query.
      cmd.CommandType   = CommandType.Text;

      // Create the SQL query with the XQuery expression.
      StringBuilder blr = new StringBuilder();
      blr.Append("SELECT COLUMN_VALUE FROM XMLTable");
      blr.Append("(\'for $i in fn:collection(\"oradb:/OE/PURCHASEORDER\") ");
      blr.Append("   where count($i/PurchaseOrder/LineItems/LineItem) = $itemno ");
      blr.Append("      and $i/PurchaseOrder/LineItems/LineItem/Part/@Id = $id ");
      blr.Append("   return $i/PurchaseOrder/LineItems\' ");
      blr.Append("  PASSING :nbitems AS \"itemno\", :partid AS \"id\")");

      cmd.CommandText = blr.ToString();
      cmd.Parameters.Add(":nbitems", OracleDbType.Int16, 3, ParameterDirection.Input);
      cmd.Parameters.Add(":partid", OracleDbType.Varchar2, "715515009058", ParameterDirection.Input);
```

```
      // Get the XML document as an XmlReader.
      OracleDataReader dr = cmd.ExecuteReader();
      dr.Read();

      // Get the XMLType column as an OracleXmlType
      OracleXmlType xml = dr.GetOracleXmlType(0);

      // Print the XML data in the OracleXmlType object
      Console.WriteLine(xml.Value);
      xml.Dispose();

      // Clean up.
      cmd.Dispose();
      con.Close();
      con.Dispose();
    }
  }
}
```

This produces the following output:

```
<LineItems>
  <LineItem ItemNumber="1">
    <Description>Samurai 2: Duel at Ichijoji Temple</Description>
    <Part Id="37429125526" UnitPrice="29.95" Quantity="3"/>
  </LineItem>
  <LineItem ItemNumber="2">
    <Description>The Red Shoes</Description>
    <Part Id="37429128220" UnitPrice="39.95" Quantity="4"/>
  </LineItem>
  <LineItem ItemNumber="3">
    <Description>A Night to Remember</Description>
    <Part Id="715515009058" UnitPrice="39.95" Quantity="1"/>
  </LineItem>
</LineItems>
```

See Also:

- Chapter 11, "PL/SQL APIs for XMLType"
- Chapter 13, "Java DOM API for XMLType"
- Chapter 15, "Oracle XML DB and Oracle Data Provider for .NET"

Updating XML Data

This section covers updating XML data, both transient data and data stored in tables.

Updating an Entire XML Document

To update an entire XML document, use a SQL `UPDATE` statement. The right side of the `UPDATE` statement `SET` clause must be an `XMLType` instance. This can be created in any of the following ways:

- Use SQL functions or XML constructors that return an XML instance.
- Use the PL/SQL DOM APIs for `XMLType` that change and bind an existing XML instance.
- Use the Java DOM API that changes and binds an existing XML instance.

Updates for non-schema-based documents stored as binary XML can be made in a piecewise manner.

Example 5–27 updates an `XMLType` instance using a SQL `UPDATE` statement.

Example 5–27 Updating XMLType Data Using SQL UPDATE

```
SELECT t.reference, li.lineno, li.description
  FROM purchaseorder po,
       XMLTable('$p/PurchaseOrder' PASSING po.OBJECT_VALUE AS "p"
                COLUMNS reference VARCHAR2(28) PATH 'Reference',
                        lineitem  XMLType      PATH 'LineItems/LineItem') t,
       XMLTable('$l/LineItem' PASSING t.lineitem AS "l"
                COLUMNS lineno      NUMBER(10)    PATH '@ItemNumber',
                        description VARCHAR2(128) PATH 'Description') li
  WHERE t.reference = 'DAUSTIN-20021009123335811PDT' AND ROWNUM < 6;

REFERENCE                       LINENO DESCRIPTION
------------------------------- ------- -----------------
DAUSTIN-20021009123335811PDT          1 Nights of Cabiria
DAUSTIN-20021009123335811PDT          2 For All Mankind
DAUSTIN-20021009123335811PDT          3 Dead Ringers
DAUSTIN-20021009123335811PDT          4 Hearts and Minds
DAUSTIN-20021009123335811PDT          5 Rushmore

UPDATE purchaseorder po
  SET po.OBJECT_VALUE = XMLType(bfilename('XMLDIR','NEW-DAUSTIN-20021009123335811PDT.xml'),
                                nls_charset_id('AL32UTF8'))
  WHERE XMLExists('$p/PurchaseOrder[Reference="DAUSTIN-20021009123335811PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

SELECT t.reference, li.lineno, li.description
  FROM purchaseorder po,
       XMLTable('$p/PurchaseOrder' PASSING po.OBJECT_VALUE AS "p"
                COLUMNS reference VARCHAR2(28) PATH 'Reference',
                        lineitem  XMLType      PATH 'LineItems/LineItem') t,
       XMLTable('$l/LineItem' PASSING t.lineitem AS "l"
                COLUMNS lineno      NUMBER(10)    PATH '@ItemNumber',
                        description VARCHAR2(128) PATH 'Description') li
  WHERE t.reference = 'DAUSTIN-20021009123335811PDT';

REFERENCE                       LINENO DESCRIPTION
------------------------------- ------- --------------------------------
DAUSTIN-20021009123335811PDT          1 Dead Ringers
DAUSTIN-20021009123335811PDT          2 Getrud
DAUSTIN-20021009123335811PDT          3 Branded to Kill
```

Replacing XML Nodes

Example 5–28 uses XQuery Update on the right side of a SQL `UPDATE` statement to update an existing XML document instead of creating a new document. The entire document is updated, not just the part of it that is selected.

Example 5–28 Updating XMLTYPE Data Using SQL UPDATE and XQuery Update

```
SELECT XMLQuery('$p/PurchaseOrder/Actions/Action[1]' PASSING po.OBJECT_VALUE AS "p"
                                                     RETURNING CONTENT) action
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

ACTION
--------------------------------
<Action>
  <User>SVOLLMAN</User>
</Action>
```

```
UPDATE purchaseorder po
  SET po.OBJECT_VALUE =
    XMLQuery('copy $i := $p1 modify
               (for $j in $i/PurchaseOrder/Actions/Action[1]/User
                return replace value of node $j with $p2)
               return $i' PASSING po.OBJECT_VALUE AS "p1",
                                  'SKING' AS "p2" RETURNING CONTENT)
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

SELECT XMLQuery('$p/PurchaseOrder/Actions/Action[1]' PASSING po.OBJECT_VALUE AS "p"
                                                     RETURNING CONTENT) action
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

ACTION
--------------------------------
<Action>
  <User>SKING</User>
</Action>
```

Note that in Example 5–28 we pass the SQL string literal `'SKING'` to the XQuery expression as a variable (`$p2`). In this simple example, since the value is a string literal, we could have simply used `replace value of node $j with "SKING"`. That is, you can just use a literal XQuery string here, instead of passing a literal string from SQL to XQuery. In real-world examples you will typically pass a value that is available only at runtime; Example 5–28 shows how to do that. This is also true of other examples.

Example 5–29 updates multiple text nodes and attribute nodes.

Example 5–29 Updating Multiple Text Nodes and Attribute Nodes

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME            LINEITEMS
--------------- --------------------------------------------------------------------------
Sarah J. Bell   <LineItems>
                  <LineItem ItemNumber="1">
                    <Description>A Night to Remember</Description>
                    <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="2">
                    <Description>The Unbearable Lightness Of Being</Description>
                    <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="3">
                    <Description>Sisters</Description>
                    <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                  </LineItem>
                </LineItems>

UPDATE purchaseorder
  SET OBJECT_VALUE =
    XMLQuery('copy $i := $p1 modify
```

```
               ((for $j in $i/PurchaseOrder/Requestor
                 return replace value of node $j with $p2),
                (for $j in $i/PurchaseOrder/LineItems/LineItem[1]/Part/@Id
                 return replace value of node $j with $p3),
                (for $j in $i/PurchaseOrder/LineItems/LineItem[1]/Description
                 return replace value of node $j with $p4),
                (for $j in $i/PurchaseOrder/LineItems/LineItem[3]
                 return replace node $j with $p5))
              return $i'
            PASSING OBJECT_VALUE AS "p1",
                    'Stephen G. King' AS "p2",
                    '786936150421' AS "p3",
                    'The Rock' AS "p4",
                    XMLType('<LineItem ItemNumber="99">
                               <Description>Dead Ringers</Description>
                               <Part Id="715515009249" UnitPrice="39.95" Quantity="2"/>
                             </LineItem>') AS "p5"
            RETURNING CONTENT)
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME             LINEITEMS
---------------- --------------------------------------------------------------
Stephen G. King  <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>The Rock</Description>
                     <Part Id="786936150421" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="2">
                     <Description>The Unbearable Lightness Of Being</Description>
                     <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="99">
                     <Description>Dead Ringers</Description>
                     <Part Id="715515009249" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                 </LineItems>
```

Example 5–30 updates selected nodes within a collection.

Example 5–30 Updating Selected Nodes within a Collection

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME             LINEITEMS
---------------- --------------------------------------------------------------
Sarah J. Bell    <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>A Night to Remember</Description>
```

```
                  <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
                </LineItem>
                <LineItem ItemNumber="2">
                  <Description>The Unbearable Lightness Of Being</Description>
                  <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                </LineItem>
                <LineItem ItemNumber="3">
                  <Description>Sisters</Description>
                  <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                </LineItem>
              </LineItems>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      XMLQuery(
        'copy $i := $p1 modify
           ((for $j in $i/PurchaseOrder/Requestor
             return replace value of node $j with $p2),
            (for $j in $i/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]/@Quantity
             return replace value of node $j with $p3),
            (for $j in $i/PurchaseOrder/LineItems/LineItem
                        [Description/text()="The Unbearable Lightness Of Being"]
             return replace node $j with $p4))
           return $i'
        PASSING OBJECT_VALUE AS "p1",
                'Stephen G. King' AS "p2",
                25 AS "p3",
                XMLType('<LineItem ItemNumber="99">
                           <Part Id="786936150421" Quantity="5" UnitPrice="29.95"/>
                           <Description>The Rock</Description>
                         </LineItem>') AS "p4"
        RETURNING CONTENT)
      WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                      PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME             LINEITEMS
---------------- ------------------------------------------------------------
Stephen G. King  <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>A Night to Remember</Description>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity="25"/>
                   </LineItem>
                   <LineItem ItemNumber="99">
                     <Part Id="786936150421" Quantity="5" UnitPrice="29.95"/>
                     <Description>The Rock</Description>
                   </LineItem>
                   <LineItem ItemNumber="3">
                     <Description>Sisters</Description>
                     <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                   </LineItem>
                 </LineItems>
```

Example 5–31 illustrates the common mistake of using an XQuery Update replace-value operation to update a *node that occurs multiple times* in a collection. The `UPDATE` statement sets the value of the text node of a `Description` element to `The Wizard of Oz`, where the current value of the text node is `Sisters`. The statement includes an `XMLExists` expression in the `WHERE` clause that identifies the set of nodes to be updated.

Example 5–31 Incorrectly Updating a Node That Occurs Multiple Times in a Collection

```
SELECT XMLCast(des.COLUMN_VALUE AS VARCHAR2(256))
  FROM purchaseorder,
       XMLTable('$p/PurchaseOrder/LineItems/LineItem/Description'
                PASSING OBJECT_VALUE AS "p") des
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLCAST(DES.COLUMN_VALUEASVARCHAR2(256))
----------------------------------------
The Lady Vanishes
The Unbearable Lightness Of Being
Sisters

3 rows selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
        XMLQuery('copy $i := $p1 modify
                    (for $j in $i/PurchaseOrder/LineItems/LineItem/Description
                     return replace value of node $j with $p2)
                  return $i'
                 PASSING OBJECT_VALUE AS "p1", 'The Wizard of Oz' AS "p2"
                 RETURNING CONTENT)
        WHERE
XMLExists('$p/PurchaseOrder/LineItems/LineItem[Description="Sisters"]'
                        PASSING OBJECT_VALUE AS "p")
          AND XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                        PASSING OBJECT_VALUE AS "p");

1 row updated.

SELECT XMLCast(des.COLUMN_VALUE AS VARCHAR2(256))
  FROM purchaseorder,
       XMLTable('$p/PurchaseOrder/LineItems/LineItem/Description'
                PASSING OBJECT_VALUE AS "p") des
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLCAST(DES.COLUMN_VALUEASVARCHAR2(256))
----------------------------------------
The Wizard of Oz
The Wizard of Oz
The Wizard of Oz

3 rows selected.
```

Instead of updating only the intended node, Example 5–31 updates the values of *all* text nodes that belong to the `Description` element. This is not what was intended.

*A `WHERE` clause can be used only to identify which **documents** must be updated, not which **nodes** within a document must be updated.*

After the document has been selected, the *XQuery expression* passed to XQuery Update determines which *nodes* within the document must be updated. In this case, the XQuery expression identifies all three `Description` nodes, so all three of the associated text nodes were updated.

To correctly update a node that occurs multiple times within a collection, use the XQuery expression passed XQuery Update to identify which nodes in the XML document to update. By introducing the appropriate predicate into the XQuery expression, you can limit which nodes in the document are updated. Example 5–32 illustrates the correct way to update one node within a collection.

Example 5–32 Correctly Updating a Node That Occurs Multiple Times in a Collection

```
SELECT XMLCast(des.COLUMN_VALUE AS VARCHAR2(256))
  FROM purchaseorder,
       XMLTable('$p/PurchaseOrder/LineItems/LineItem/Description'
                PASSING OBJECT_VALUE AS "p") des
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLCAST(DES.COLUMN_VALUEASVARCHAR2(256))
----------------------------------------

A Night to Remember
The Unbearable Lightness Of Being
Sisters

3 rows selected.


UPDATE purchaseorder
 SET OBJECT_VALUE =
       XMLQuery('copy $i := $p1 modify
                   (for $j in $i/PurchaseOrder/LineItems/LineItem/Description
                               [text()="Sisters"]
                    return replace value of node $j with $p2)
                 return $i'
                PASSING OBJECT_VALUE       AS "p1",
                        'The Wizard of Oz' AS "p2" RETURNING CONTENT)
       WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                       PASSING OBJECT_VALUE AS "p");

1 row updated.

SELECT XMLCast(des.COLUMN_VALUE AS VARCHAR2(256))
  FROM purchaseorder,
       XMLTable('$p/PurchaseOrder/LineItems/LineItem/Description'
                PASSING OBJECT_VALUE AS "p") des
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLCAST(DES.COLUMN_VALUEASVARCHAR2(256))
----------------------------------------
A Night to Remember
The Unbearable Lightness Of Being
The Wizard of Oz
```

```
3 rows selected.
```

Updating XML Data to NULL Values

The following considerations apply to updating XML data to NULL values.

- If you update an XML *element* to NULL, the attributes and children of the element are removed, and the element becomes empty. The type and namespace properties of the element are retained. See Example 5–33.
- If you update an *attribute* value to NULL, the value appears as the empty string. See Example 5–33.
- If you update the *text* node of an element to NULL, the content (text) of the element is removed. The element itself remains, but it is empty. See Example 5–34.

Example 5–33 updates all of the following to NULL:

- The Description element and the Quantity attribute of the LineItem element whose Part element has attribute Id value 715515009058.
- The LineItem element whose Description element has the content (text) "The Unbearable Lightness Of Being".

Example 5–33 NULL Updates – Element and Attribute

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME            LINEITEMS
--------------- --------------------------------------------------------------------
Sarah J. Bell   <LineItems>
                  <LineItem ItemNumber="1">
                    <Description>A Night to Remember</Description>
                    <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="2">
                    <Description>The Unbearable Lightness Of Being</Description>
                    <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="3">
                    <Description>Sisters</Description>
                    <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                  </LineItem>
                </LineItems>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      XMLQuery(
        'copy $i := $p1 modify
           ((for $j in $i/PurchaseOrder/LineItems/LineItem[Part/@Id="715515009058"]/Description
             return replace value of node $j with ()) ,
            (for $j in $i/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]/@Quantity
             return replace value of node $j with ()) ,
            (for $j in $i/PurchaseOrder/LineItems/LineItem
```

```
                        [Description/text()= "The Unbearable Lightness Of Being"]
            return replace node $j with $p2))
         return $i'
        PASSING OBJECT_VALUE AS "p1", NULL AS "p2"
        RETURNING CONTENT)
     WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                     PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME             LINEITEMS
---------------- --------------------------------------------------------------
Sarah J. Bell    <LineItems>
                   <LineItem ItemNumber="1">
                     <Description/>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity=""/>
                   </LineItem>
                   <LineItem/>
                   <LineItem ItemNumber="3">
                     <Description>Sisters</Description>
                     <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                   </LineItem>
                 </LineItems>
```

Note that Example 5–33 shows two different but equivalent ways to remove the value of a node. For element `Description` and attribute `Quantity`, a literal XQuery empty sequence, `()`, replaces the existing value directly. For element `LineItem`, SQL **`NULL`** is passed into the XQuery expression to provide the empty node value. Since the value used is literal, it is simpler not to pass it from SQL to XQuery. But in real-world examples you will often pass a value that is available only at runtime. Example 5–33 shows how to do this for an empty XQuery sequence: pass a SQL `NULL` value.

Example 5–34 updates the text node of a `Part` element whose `Description` attribute has value "`A Night to Remember`" to `NULL`. The XML data for this example corresponds to a different, revised purchase-order XML schema – see "Scenario for Copy-Based Evolution" on page 20-2. In that XML schema, `Description` is an attribute of the `Part` element, not a sibling element.

Example 5–34 NULL Updates – Text Node

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(128)) part
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[@Reference="SBELL-2003030912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

PART
----
<Part Description="A Night to Remember" UnitCost="39.95">715515009058</Part>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      XMLQuery(
```

```
       'copy $i := $p1 modify
          (for $j in $i/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]
           return replace value of node $j with $p2)
        return $i
       PASSING OBJECT_VALUE AS "p1", NULL AS "p2" RETURNING CONTENT)
  WHERE XMLExists('$p/PurchaseOrder[@Reference="SBELL-20030309123336O1PDT"]'
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(128)) part
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[@Reference="SBELL-20030309123336O1PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

PART
----
<Part Description="A Night to Remember" UnitCost="39.95"/>
```

See Also: Example 3–26, "Updating a Text Node"

Inserting Child XML Nodes

This section shows how to use XQuery Update to insert new children (either a single attribute or one or more elements of the same type) under parent XML elements. The XML document that is the target of the insertion can be schema-based or non-schema-based.

Example 5–35 inserts a new `LineItem` element as a child of element `LineItems`. Note that it uses the Oracle XQuery pragma `ora:child-element-name` to specify the name of the inserted child element as `LineItem`.

Example 5–35 Inserting an Element into a Collection

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[@ItemNumber=222]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER=222]'
--------------------------------------------------------------

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
      XMLQuery('copy $i := $p1 modify
                  (for $j in $i/PurchaseOrder/LineItems
                   return (# ora:child-element-name LineItem #)
                          {insert node $p2 into $j})
                return $i'
               PASSING OBJECT_VALUE AS "p1",
                       XMLType('<LineItem ItemNumber="222">
                                  <Description>The Harder They Come</Description>
                                  <Part Id="953562951413" UnitPrice="22.95" Quantity="1"/>
                                </LineItem>') AS "p2"
               RETURNING CONTENT)
      WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                      PASSING OBJECT_VALUE AS "p");
```

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[@ItemNumber=222]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER=222]'
--------------------------------------------------------------
<LineItem ItemNumber="222">
  <Description>The Harder They Come</Description>
  <Part Id="953562951413" UnitPrice="22.95" Quantity="1"/>
</LineItem>

1 row selected.
```

If the XML data to be updated is XML schema-based and it refers to a namespace, then the data to be inserted must also refer to the same namespace. Otherwise, an error is raised because the inserted data does not conform to the XML schema.

Example 5–36 is the same as Example 5–35, except that the `LineItem` element to be inserted refers to a namespace. This assumes that the relevant XML schema requires a namespace for this element.

Example 5–36 Inserting an Element that Uses a Namespace

```
UPDATE purchaseorder
  SET OBJECT_VALUE =
      XMLQuery('declare namespace e = "films.xsd"; (: :)
                copy $i := $p1 modify
                  (for $j in $i/PurchaseOrder/LineItems
                   return (# ora:child-element-name e:LineItem #)
                          {insert node $p2 into $j})
                return $i'
               PASSING OBJECT_VALUE AS "p1",
                       XMLType('<e:LineItem ItemNumber="222">
                                  <Description>The Harder They Come</Description>
                                  <Part Id="953562951413" UnitPrice="22.95" Quantity="1"/>
                                </e:LineItem>') AS "p2"
               RETURNING CONTENT)
      WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                      PASSING OBJECT_VALUE AS "p");
```

Example 5–37 inserts a `LineItem` element before the first `LineItem` element.

Example 5–37 Inserting an Element Before an Element

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[1]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[1]'PASSINGPO.OBJECT_
--------------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>Salesman</Description>
  <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
</LineItem>

UPDATE purchaseorder
```

```
  SET OBJECT_VALUE =
      XMLQuery('copy $i := $p1 modify
                  (for $j in $i/PurchaseOrder/LineItems/LineItem[1]
                   return insert node $p2 before $j)
                return $i'
               PASSING OBJECT_VALUE AS "p1",
                       XMLType('<LineItem ItemNumber="314">
                                  <Description>Brazil</Description>
                                  <Part Id="314159265359" UnitPrice="69.95"
                                        Quantity="2"/>
                                </LineItem>') AS "p2"
               RETURNING CONTENT)
      WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                      PASSING OBJECT_VALUE AS "p");

SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[position() <= 2]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[POSITION()<=2]'PASSINGPO.OBJECT_
--------------------------------------------------------------------------------
<LineItem ItemNumber="314">
  <Description>Brazil</Description>
  <Part Id="314159265359" UnitPrice="69.95" Quantity="2"/>
</LineItem>
<LineItem ItemNumber="1">
  <Description>Salesman</Description>
  <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
</LineItem>
```

Example 5–38 inserts a `Date` element as the last child of an `Action` element.

Example 5–38 Inserting an Element as the Last Child Element

```
SELECT XMLQuery('$p/PurchaseOrder/Actions/Action[1]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/ACTIONS/ACTION[1]'PASSINGPO.OBJECT_VALUE
----------------------------------------------------------------
<Action>
  <User>KPARTNER</User>
</Action>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      XMLQuery('copy $i := $p1 modify
                  (for $j in $i/PurchaseOrder/Actions/Action[1]
                   return insert nodes $p2 as last into $j)
                return $i'
               PASSING OBJECT_VALUE AS "p1",
                       XMLType('<Date>2002-11-04</Date>') AS "p2"
               RETURNING CONTENT)
      WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                      PASSING OBJECT_VALUE AS "p");
```

```
SELECT XMLQuery('$p/PurchaseOrder/Actions/Action[1]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/ACTIONS/ACTION[1]'PASSINGPO.OBJECT_VALUE
--------------------------------------------------------------------
<Action>
  <User>KPARTNER</User>
  <Date>2002-11-04</Date>
</Action>
```

Deleting XML Nodes

Example 5–39 deletes the `LineItem` element whose `ItemNumber` attribute has value `222`.

Example 5–39 Deleting an Element

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[@ItemNumber=222]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER=222]'PASSINGPO
--------------------------------------------------------------------------
<LineItem ItemNumber="222">
  <Description>The Harder They Come</Description>
  <Part Id="953562951413" UnitPrice="22.95" Quantity="1"/>
</LineItem>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      XMLQuery('copy $i := $p modify
                  delete nodes $i/PurchaseOrder/LineItems/LineItem[@ItemNumber="222"]
                return $i'
               PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
      WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                      PASSING OBJECT_VALUE AS "p");

SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[@ItemNumber=222]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER=222]'PASSINGPO
--------------------------------------------------------------------------

1 row selected.
```

Creating XML Views of Modified XML Data

You can use XQuery Update to create new views of XML data.

Example 5–40 creates a view of table `purchaseorder`.

Example 5–40 Creating a View Using Updated XML Data

```
CREATE OR REPLACE VIEW purchaseorder_summary OF XMLType AS
  SELECT XMLQuery('copy $i := $p1 modify
                     ((for $j in $i/PurchaseOrder/Actions
                       return replace value of node $j with ()),
                      (for $j in $i/PurchaseOrder/ShippingInstructions
                       return replace value of node $j with ()),
                      (for $j in $i/PurchaseOrder/LineItems
                       return replace value of node $j with ()))
                   return $i'
                  PASSING OBJECT_VALUE AS "p1" RETURNING CONTENT)
    FROM purchaseorder p;

SELECT OBJECT_VALUE FROM purchaseorder_summary
  WHERE XMLExists('$p/PurchaseOrder[Reference="DAUSTIN-20021009123335811PDT"]'
                  PASSING OBJECT_VALUE AS "p");

OBJECT_VALUE
--------------------------------------------------------------------------------
<PurchaseOrder
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation=
      "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
  <Reference>DAUSTIN-20021009123335811PDT</Reference>
  <Actions/>
  <Reject/>
  <Requestor>David L. Austin</Requestor>
  <User>DAUSTIN</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions/>
  <SpecialInstructions>Courier</SpecialInstructions>
  <LineItems/>
</PurchaseOrder>
```

Performance Tuning for XQuery

A SQL query that involves XQuery expressions can often be automatically rewritten (optimized) in one or more ways. This optimization is referred to as **XML query rewrite** or optimization. When this happens, the XQuery expression is, in effect, evaluated directly against the XML document without constructing a DOM in memory.

XPath expressions are a proper subset of XQuery expressions. **XPath rewrite** is a subset of XML query rewrite that involves rewriting queries that involve XPath expressions.

XPath rewrite includes all of the following:

- Single-pass streaming of `XMLType` data stored as binary XML – A set of XPath expressions is evaluated in a single scan of the data.
- `XMLIndex` optimizations – A SQL statement that uses an XPath expression is rewritten to an equivalent SQL statement that does not use it but which instead references the relational `XMLIndex` tables. The rewritten SQL statement can also make use of any B-tree indexes on the underlying `XMLIndex` tables.
- Optimizations for `XMLType` data stored object-relationally and for `XMLType` views – A SQL statement that uses an XPath expression is rewritten to an equivalent SQL statement that does not use it but which instead references the object-relational or relational data structures that underly the `XMLType` data. The rewritten SQL

statement can also make use of any B-tree indexes on the underlying data structures. This can take place for both queries and update operations.

Just as query tuning can improve SQL performance, so it can improve XQuery performance. You tune XQuery performance by choosing appropriate XML storage models and indexes.

As with database queries generally, you determine whether tuning is required by examining the execution plan for a query. If the plan is not optimal, then consult the following documentation for specific tuning information:

- For object-relational storage: Chapter 19, "XPath Rewrite for Object-Relational Storage"
- For binary XML storage: Chapter 6, "Indexes for XMLType Data"

In addition, be aware that the following expressions can be expensive to process, so they might add performance overhead when processing large volumes of data:

- SQL expressions that use the following *deprecated* Oracle SQL functions, which accept XPath expression arguments:
  - `appendChildXML` (use `insertChildXMLafter` instead)
  - `insertXMLafter` (use `insertChildXMLafter` instead)
  - `insertXMLbefore` (use `insertChildXMLbefore` instead)
- XQuery expressions that use the following axes (use forward and descendent axes instead):
  - `ancestor`
  - `ancestor-or-self`
  - `descendant-or-self`
  - `following`
  - `following-sibling`
  - `namespace`
  - `parent`
  - `preceding`
  - `preceding-sibling`
- XQuery expressions that involve node identity (for example, using the order-comparison operators << and >>)

See Also: "Oracle XML DB Support for XQuery" on page 4-25

The following sections present the execution plans for some of the examples shown in Chapter 4, "XQuery and Oracle XML DB", to indicate how they are executed.

- "XQuery Optimization over Relational Data" on page 5-41: examples with XQuery expressions that target XML data created on the fly using `fn:collection` together with URI scheme `oradb`.
- "XQuery Optimization over XML Schema-Based XMLType Data" on page 5-42: examples with XQuery expressions that target an XML schema-based `XMLType` table stored object-relationally

Rule-Based and Cost-Based XQuery Optimization

Several competing optimization possibilities can exist for queries with XQuery expressions, depending on various factors such as the `XMLType` storage model and indexing that are used.

By default, Oracle XML DB follows a prioritized set of rules to determine which of the possible optimizations should be used for any given query and context. This behavior is referred to as **rule-based** XML query rewrite.

Alternatively, Oracle XML DB can use **cost-based** XML query rewrite. In this mode, Oracle XML DB estimates the performance of the various XML optimization possibilities for a given query and chooses the combination that is expected to be most performant.

You can impose cost-based optimization for a given SQL statement by using the optimizer hint `/*+ COST_XML_QUERY_REWRITE */`.

XQuery Optimization over Relational Data

Example 5–41 shows the optimization of `XMLQuery` over relational data accessed as XML. Example 5–42 shows the optimization of `XMLTable` in the same context.

Example 5–41 Optimization of XMLQuery over Relational Data

Here again is the query of Example 5–6 on page 5-6, together with its execution plan, which shows that the query has been optimized.

```
SELECT XMLQuery(
         'for $i in fn:collection("oradb:/OE/WAREHOUSES")/ROW
          return <Warehouse id="{$i/WAREHOUSE_ID}">
                   <Location>
                     {for $j in fn:collection("oradb:/HR/LOCATIONS")/ROW
                      where $j/LOCATION_ID eq $i/LOCATION_ID
                      return ($j/STREET_ADDRESS, $j/CITY, $j/STATE_PROVINCE)}
                   </Location>
                 </Warehouse>'
        RETURNING CONTENT) FROM DUAL;

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------
Plan hash value: 3341889589

-------------------------------------------------------------------------------------------
| Id  | Operation                    | Name         | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |              |     1 |       |     2   (0)| 00:00:01 |
|   1 |  SORT AGGREGATE              |              |     1 |    41 |            |          |
|   2 |   TABLE ACCESS BY INDEX ROWID| LOCATIONS    |     1 |    41 |     1   (0)| 00:00:01 |
|*  3 |    INDEX UNIQUE SCAN         | LOC_ID_PK    |     1 |       |     0   (0)| 00:00:01 |
|   4 |  SORT AGGREGATE              |              |     1 |     6 |            |          |
|   5 |   TABLE ACCESS FULL          | WAREHOUSES   |     9 |    54 |     2   (0)| 00:00:01 |
|   6 |  FAST DUAL                   |              |     1 |       |     2   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   3 - access("LOCATION_ID"=:B1)

18 rows selected.
```

Example 5–42 Optimization of XMLTable over Relational Data

Here again is the query of Example 5–7 on page 5-8, together with its execution plan, which shows that the query has been optimized.

```
SELECT *
  FROM XMLTable(
         'for $i in fn:collection("oradb:/OE/WAREHOUSES")/ROW
          return <Warehouse id="{$i/WAREHOUSE_ID}">
                   <Location>
                     {for $j in fn:collection("oradb:/HR/LOCATIONS")/ROW
                      where $j/LOCATION_ID eq $i/LOCATION_ID
                      return ($j/STREET_ADDRESS, $j/CITY, $j/STATE_PROVINCE)}
                   </Location>
                 </Warehouse>');

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------
Plan hash value: 1021775546

-------------------------------------------------------------------------------------------
| Id  | Operation                    | Name       | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |            |     9 |    54 |     2   (0)| 00:00:01 |
|   1 |  SORT AGGREGATE              |            |     1 |    41 |            |          |
|   2 |   TABLE ACCESS BY INDEX ROWID| LOCATIONS  |     1 |    41 |     1   (0)| 00:00:01 |
|*  3 |    INDEX UNIQUE SCAN         | LOC_ID_PK  |     1 |       |     0   (0)| 00:00:01 |
|   4 |  TABLE ACCESS FULL           | WAREHOUSES |     9 |    54 |     2   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   3 - access("LOCATION_ID"=:B1)

16 rows selected.
```

XQuery Optimization over XML Schema-Based XMLType Data

Example 5–43 shows the optimization of `XMLQuery` over an XML schema-based `XMLType` table. Example 5–44 shows the optimization of `XMLTable` in the same context.

Example 5–43 Optimization of XMLQuery with Schema-Based XMLType Data

Here again is the query of Example 5–10 on page 5-11, together with its execution plan, which shows that the query has been optimized.

```
SELECT XMLQuery('for $i in /PurchaseOrder
                 where $i/CostCenter eq "A10"
                   and $i/User eq "SMCCAIN"
                 return <A10po pono="{$i/Reference}"/>'
                PASSING OBJECT_VALUE
                RETURNING CONTENT)
  FROM purchaseorder;

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------
Plan hash value: 3611789148

------------------------------------------------------------------------------------
| Id  | Operation           | Name          | Rows  | Bytes | Cost (%CPU)| Time     |
```

```
-------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT    |               |     1 |   530 |     5   (0)| 00:00:01 |
|   1 |  SORT AGGREGATE     |               |     1 |       |            |          |
|*  2 |   FILTER            |               |       |       |            |          |
|   3 |    FAST DUAL        |               |     1 |       |     2   (0)| 00:00:01 |
|*  4 |    TABLE ACCESS FULL| PURCHASEORDER |     1 |   530 |     5   (0)| 00:00:01 |
-------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - filter(:B1='SMCCAIN' AND :B2='A10')
   4 - filter(SYS_CHECKACL("ACLOID","OWNERID",xmltype('<privilege
               xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
               xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
               http://xmlns.oracle.com/xdb/acl.xsd DAV:http://xmlns.oracle.com/xdb/dav.xsd">
               <read-properties/><read-contents/></privilege>'))=1)

22 rows selected.
```

Example 5–44 Optimization of XMLTable with Schema-Based XMLType Data

Here again is the query of Example 5–14 on page 5-14, together with its execution plan, which shows that the query has been optimized. The XQuery result is never materialized. Instead, the underlying storage columns for the XML collection element `LineItem` are used to generate the overall result set.

```
SELECT lines.lineitem, lines.description, lines.partid,
       lines.unitprice, lines.quantity
  FROM purchaseorder,
       XMLTable('for $i in /PurchaseOrder/LineItems/LineItem
                 where $i/@ItemNumber >= 8
                   and $i/Part/@UnitPrice > 50
                   and $i/Part/@Quantity > 2
                 return $i'
                PASSING OBJECT_VALUE
                COLUMNS lineitem    NUMBER       PATH '@ItemNumber',
                        description VARCHAR2(30) PATH 'Description',
                        partid      NUMBER       PATH 'Part/@Id',
                        unitprice   NUMBER       PATH 'Part/@UnitPrice',
                        quantity    NUMBER       PATH 'Part/@Quantity') lines;
```

```
-----------------------------------------------------------------------------------------------
| Id  | Operation                     | Name           | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |                |     4 |   384 |     7   (0)| 00:00:01 |
|   1 |  NESTED LOOPS                 |                |       |       |            |          |
|   2 |   NESTED LOOPS                |                |     4 |   384 |     7   (0)| 00:00:01 |
|*  3 |    TABLE ACCESS FULL          | PURCHASEORDER  |     1 |    37 |     5   (0)| 00:00:01 |
|*  4 |    INDEX RANGE SCAN           | SYS_C005478    |    17 |       |     1   (0)| 00:00:01 |
|*  5 |   TABLE ACCESS BY INDEX ROWID| LINEITEM_TABLE |     3 |   177 |     2   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   3 - filter(SYS_CHECKACL("ACLOID","OWNERID",xmltype('<privilege
               xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
               xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
```

```
            http://xmlns.oracle.com/xdb/acl.xsd
            DAV:http://xmlns.oracle.com/xdb/dav.xsd"><read-prop
            erties/><read-contents/></privilege>'))=1)
   4 - access("NESTED_TABLE_ID"="PURCHASEORDER"."SYS_NC0003400035$")
   5 - filter("SYS_NC00013$">50 AND "SYS_NC00012$">2 AND "ITEMNUMBER">=8 AND
            "SYS_NC_TYPEID$" IS NOT NULL)

25 rows selected.
```

This example traverses table `oe.purchaseorder` completely. The `XMLTable` expression is evaluated for each purchase-order document. It is more efficient to have the `XMLTable` expression, not the `purchaseorder` table, drive the SQL-query execution.

Although the XQuery expression has been rewritten to relational expressions, you can improve this optimization by creating an *index* on the underlying relational data—you can optimize this query in the same way that you would optimize a purely SQL query. That is always the case with XQuery in Oracle XML DB: the optimization techniques you use are the same as those you use in SQL.

The `UnitPrice` attribute of collection element `LineItem` is an appropriate index target. The governing XML schema specifies that an ordered collection table (OCT) is used to store the `LineItem` elements.

However, the name of this OCT was generated by Oracle XML DB when the XML purchase-order documents were decomposed as XML schema-based data. Instead of using table `purchaseorder` from sample database schema `HR`, you could manually create a new `purchaseorder` table (in a different database schema) with the same properties and same data, but having OCTs with user-friendly names.

Assuming that this has been done, the following statement creates the appropriate index:

```
CREATE INDEX unitprice_index ON lineitem_table("PART"."UNITPRICE");
```

With this index defined, the query of Example 5–14 on page 5-14 results in the following execution plan, which shows that the `XMLTable` expression has driven the overall evaluation.

```
PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------
Plan hash value: 1578014525

-------------------------------------------------------------------------------------------
| Id  | Operation          | Name              | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT   |                   |     3 |   624 |     8   (0)| 00:00:01 |
|   1 |  NESTED LOOPS      |                   |     3 |   624 |     8   (0)| 00:00:01 |
|*  2 |   INDEX UNIQUE SCAN| SYS_IOT_TOP_49323 |     3 |   564 |     5   (0)| 00:00:01 |
|*  3 |    INDEX RANGE SCAN| UNITPRICE_INDEX   |    20 |       |     2   (0)| 00:00:01 |
|*  4 |   INDEX UNIQUE SCAN| SYS_C004411       |     1 |       |     0   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - access("SYS_NC00013$">50)
       filter("ITEMNUMBER">=8 AND "SYS_NC00012$">2)
   3 - access("SYS_NC00013$">50)
   4 - access("NESTED_TABLE_ID"="PURCHASEORDER"."SYS_NC0003400035$")

Note
-----
   - dynamic sampling used for this statement
```

```
23 rows selected.
```

Diagnosing XQuery Optimization: XMLOptimizationCheck

You can examine an execution plan for your SQL code to determine whether XQuery optimization occurs or the plan is instead suboptimal. In the latter case, a note such as the following appears immediately after the plan:

```
Unoptimized XML construct detected (enable XMLOptimizationCheck
for more information)
```

You can also compare the execution plan output with the plan output that you see after you use the optimizer hint `NO_XML_QUERY_REWRITE`, which turns off XQuery optimization.

In addition, you can use the SQL*Plus `SET` command with system variable `XMLOptimizationCheck` to turn on an **XML diagnosability mode** for SQL:

```
SET XMLOptimizationCheck ON
```

When this mode is on, the plan of execution is automatically checked for XQuery optimization, and if the plan is suboptimal then an error is raised and diagnostic information is written to the trace file indicating which operators are not rewritten.

The main advantage of `XMLOptimizationCheck` is that it brings a potential problem to your attention immediately. For this reason, you might find it preferable to leave it turned on at all times. Then, if an application change or a database change for some reason prevents a SQL operation from rewriting, execution is stopped instead of performance being negatively impacted without your being aware of the cause.

Note:

- `XMLOptimizationCheck` was not available prior to Oracle Database 11g Release 2 (11.2.0.2). Users of older releases directly manipulated event 19201 to obtain XQuery optimization information.
- OCI users can use `OCIStmtExecute` or event 19201. Only the event is available to Java users.

See Also: "Turning Off Use of XMLIndex" on page 6-32 for information about optimizer hint `NO_XML_QUERY_REWRITE`

Improving Performance for fn:doc and fn:collection on Repository Data

In Oracle XML DB, you can use XQuery functions `fn:doc` and `fn:collection` to reference documents and collections in Oracle XML DB Repository. When repository XML data is stored object-relationally or as binary XML, queries that use `fn:doc` and `fn:collection` are evaluated functionally; that is, they are not optimized to access the underlying storage tables directly.

To improve the performance of such queries, you must link them to the actual database tables that hold the repository data being queried. You can do that in either of the following ways:

- Join view `RESOURCE_VIEW` with the `XMLType` table that holds the data, and then use the Oracle SQL functions `equals_path` and `under_path` instead of the XQuery

functions `fn:doc` and `fn:collection`, respectively. These SQL functions reference repository resources in a performant way.

- Use the Oracle XQuery extension-expression pragma `ora:defaultTable`.

Both methods have the same effect. Oracle recommends that you use the `ora:defaultTable` pragma because it lets you continue to use the XQuery standard functions `fn:doc` and `fn:collection` and it simplifies your code.

These two methods are illustrated in the examples of this section.

Using EQUALS_PATH and UNDER_PATH Instead of fn:doc and fn:collection

SQL function `equals_path` references a resource located at a specified repository path, and SQL function `under_path` references a resource located under a specified repository path. Example 5–45 and Example 5–46 illustrate this for functions `fn:doc` and `equals_path`; functions `fn:collection` and `under_path` are treated similarly.

Example 5–45 Unoptimized Repository Query Using fn:doc

```
SELECT XMLQuery('let $val :=
                    fn:doc("/home/OE/PurchaseOrders/2002/Sep/VJONES-20021009123337583PDT.xml")
                    /PurchaseOrder/LineItems/LineItem[@ItemNumber =19]
                return $val' RETURNING CONTENT)
  FROM DUAL;
```

Example 5–46 Optimized Repository Query Using EQUALS_PATH

```
SELECT XMLQuery('let $val := $DOC/PurchaseOrder/LineItems/LineItem[@ItemNumber = 19]
                return $val' PASSING OBJECT_VALUE AS "DOC" RETURNING CONTENT)
  FROM RESOURCE_VIEW rv, purchaseorder p
  WHERE ref(p) = XMLCast(XMLQuery('declare default element namespace
                                  "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                                  fn:data[1](/Resource/XMLRef)' PASSING rv.RES RETURNING CONTENT)
                         AS REF XMLType)
    AND equals_path(rv.RES, '/home/OE/PurchaseOrders/2002/Sep/VJONES-20021009123337583PDT.xml')
        = 1;
```

Using Oracle XQuery Pragma ora:defaultTable

Oracle XQuery extension-expression pragma `ora:defaultTable` lets you specify the default table used to store repository data that you query. The query is rewritten to automatically join the default table to view `RESOURCE_VIEW` and use Oracle SQL functions `equals_path` and `under_path` instead of XQuery functions `fn:doc` and `fn:collection`, respectively. The effect is thus the same as coding the query manually to use an explicit join and `equals_path` or `under_path`. Example 5–47 illustrates this; the query is rewritten automatically to what is shown in Example 5–46.

Example 5–47 Repository Query Using Oracle XQuery Pragma ora:defaultTable

```
SELECT XMLQuery('for $doc in (#ora:defaultTable PURCHASEORDER #)
                            {fn:doc("/home/OE/PurchaseOrders/2002/Sep/VJONES-20021009123337583PDT.xml")}
                let $val := $doc/PurchaseOrder/LineItems/LineItem[@ItemNumber = 19]
                  return $val}'
               RETURNING CONTENT)
  FROM DUAL;
```

[1] XQuery function `fn:data` is used here to atomize its argument, in this case returning the `XMLRef` node's typed atomic value.

For clarity of scope Oracle recommends that you apply pragma `ora:defaultTable` directly to the relevant document or collection expression, `fn:doc` or `fn:collection`, rather than to a larger expression.

6

Indexes for XMLType Data

You can create indexes on your XML data, to focus on particular parts of it that you query often and thus improve performance. This chapter includes guidelines for doing this. It describes various ways that you can index `XMLType` data, whether schema-based or non-schema-based, and regardless of the `XMLType` storage model you use.

This chapter contains these topics:

Note: The execution plans shown here are for illustration only. If you run the examples presented here in your environment then your execution plans might not be identical.

See Also:

- *Oracle Database Concepts* for an overview of indexing
- *Oracle Database Development Guide* for information about using indexes in application development

Oracle XML DB Tasks Involving Indexes

Table 6–1 identifies the documentation for some basic user tasks involving indexes for XML data.

Table 6–1 Basic XML Indexing Tasks

For information about how to...	See...
Choose an indexing approach	"Overview of Indexing XMLType Data" on page 6-4
Index `XMLType` data stored object-relationally	"Indexing XMLType Data Stored Object-Relationally" on page 6-54, "Guideline: Create indexes on ordered collection tables" on page 19-8
Create, drop, or rename an `XMLIndex` index	Example 6–5 on page 6-17, Example 6–7 on page 6-18
Obtain the name of an `XMLIndex` index for a given table or column	Example 6–6 on page 6-18
Determine whether a given `XMLIndex` index is used in evaluating a query	"How to Tell Whether XMLIndex is Used" on page 6-27
Turn off use of an `XMLIndex` index	"Turning Off Use of XMLIndex" on page 6-32

Table 6–2 identifies the documentation for some user tasks involving `XMLIndex` indexes that have a *structured* component.

Table 6–2 Tasks Involving XMLIndex Indexes with a Structured Component

For information about how to...	See...
Create an `XMLIndex` index with a structured component	Example 6–20 on page 6-24, Example 6–19 on page 6-23
Drop the structured component of an `XMLIndex` index (drop all structure groups)	Example 6–22 on page 6-27
Ensure data type correspondence between a query and an `XMLIndex` index with a structured component	"Data Type Considerations for XMLIndex Structured Component" on page 6-10
Create a B-tree index on a content table of an `XMLIndex` structured component	Example 6–23 on page 6-27
Create an Oracle Text `CONTEXT` index on a content table of an `XMLIndex` structured component	Example 6–43 on page 6-52

Table 6–3 identifies the documentation for some user tasks involving `XMLIndex` indexes that have an *unstructured* component.

Table 6–3 Tasks Involving XMLIndex Indexes with an Unstructured Component

For information about how to...	See...
Create an `XMLIndex` index with an unstructured component	Example 6–8 on page 6-18, Example 6–10 on page 6-19, Example 6–30 on page 6-33, Example 6–32 on page 6-34, Example 6–33 on page 6-36, Example 6–34 on page 6-36, Example 6–35 on page 6-38
Drop the unstructured component of an `XMLIndex` index (drop the path table)	Example 6–11 on page 6-19
Name the path table when creating an `XMLIndex` index	Example 6–8 on page 6-18
Specify storage options when creating an `XMLIndex` index	Example 6–10 on page 6-19
Show all existing secondary indexes on an `XMLIndex` path table	Example 6–12 on page 6-20, Example 6–18 on page 6-21

Table 6–3 (Cont.) Tasks Involving XMLIndex Indexes with an Unstructured Component

For information about how to...	See...
Obtain the name of a path table for an XMLIndex index	Example 6–9 on page 6-19
Obtain the name of an XMLIndex index with an unstructured component, given its path table	Example 6–25 on page 6-28
Create a secondary index on an XMLIndex path table	"Using XMLIndex with an Unstructured Component" on page 6-18
Obtain information about all of the secondary indexes on an XMLIndex path table	Example 6–18 on page 6-21
Create a function-based index on a path-table VALUE column	Example 6–13 on page 6-20
Create a numeric index on a path-table VALUE column	Example 6–15 on page 6-21
Create a date index on a path-table VALUE column	Example 6–16 on page 6-21
Create an Oracle Text CONTEXT index on a path-table VALUE column	Example 6–17 on page 6-21
Exclude or include particular XPath expressions from use by an XMLIndex index	"XMLIndex Path Subsetting: Specifying the Paths You Want to Index" on page 6-32
Specify namespace prefixes for XPath expressions used for XMLIndex	"XMLIndex Path Subsetting: Specifying the Paths You Want to Index" on page 6-32
Exclude or include particular XPath expressions from use by an XMLIndex index	"XMLIndex Path Subsetting: Specifying the Paths You Want to Index" on page 6-32
Specify namespace prefixes for XPath expressions used for XMLIndex	"XMLIndex Path Subsetting: Specifying the Paths You Want to Index" on page 6-32

Table 6–4 identifies the documentation for some other user tasks involving XMLIndex indexes.

Table 6–4 Miscellaneous Tasks Involving XMLIndex Indexes

For information about how to...	See...
Specify that an XMLIndex index should be created and maintained using parallel processes	"XMLIndex Partitioning and Parallelism" on page 6-36
Change the parallelism of an XMLIndex path table to tune index performance	"XMLIndex Partitioning and Parallelism" on page 6-36
Schedule maintenance for an XMLIndex index	"Asynchronous (Deferred) Maintenance of XMLIndex Indexes" on page 6-37
Manually synchronize an XMLIndex index and its base table	"Asynchronous (Deferred) Maintenance of XMLIndex Indexes" on page 6-37
Collect statistics on a table or index for the cost-based optimizer	Example 6–37 on page 6-39
Create an XML search index	Example 6–38 on page 6-49
Use an XML search index for full-text search of XML data stored as binary XML	Example 6–39 on page 6-50
Show whether an XML search index is used in a query	Example 6–40 on page 6-50
Create an Oracle Text CONTEXT index on a content table of an XMLIndex structured component	Example 6–43 on page 6-52

Overview of Indexing XMLType Data

Database indexes improve performance by providing faster access to table data. The use of indexes is particularly recommended for online transaction processing (OLTP) environments involving few updates.

The principle way you index XML data is using `XMLIndex`. You can also use Oracle Text `CONTEXT` indexes to supplement the use of `XMLIndex`.

Here is a summary decision tree, as the place to start when choosing ways to index `XMLType` data stored as binary XML:[1]

If your XML data contains islands of structured, predictable data, and your queries are known

Use `XMLIndex` with a *structured component* to index the structured islands (even if the data surrounding these islands is unstructured).

A structured index component reflects the queries you use. You can change this set of known queries over time, provided you update the index definition accordingly. See "XMLIndex Structured Component" on page 6-8.

If you need to query full-text content within your XML data

Use an *XML search index*. See "Oracle Text Indexes for XML Data" on page 6-5.

If you need to support ad-hock XML queries that involve predicates

Use `XMLIndex` with an *unstructured component* – see "XMLIndex Unstructured Component" on page 6-12.

XMLIndex Addresses the Fine-Grained Structure of XML Data

You can create indexes on one or more table columns, or on a functional expression. XML data, however, has its own, fine-grained structure, which is not necessarily reflected in the structure of the database tables used to store it. For this reason, effectively indexing XML data can be a bit different from indexing most database data.

For object-relational `XMLType` storage, XML objects such as elements and attributes correspond to object-relational columns and tables. Creating *B-tree indexes* on those columns and tables thus provides an excellent way to effectively index the corresponding XML objects. Here, the storage model directly reflects the fine-grained structure of the XML data, so there is no special problem for indexing structured XML data. See "Indexing XMLType Data Stored Object-Relationally" on page 6-54.

In object-relational `XMLType` storage, an XML document is broken up and stored object-relationally, but you can choose to store one or more of its XML fragments as embedded `CLOB` instances. A typical use case for this is mapping an XML-schema `complexType` or a complex element to `CLOB` storage, because you generally access the entire fragment as a unit.

But such an embedded `CLOB` fragment also acts as an opaque unit when it comes to indexing; its parts are not indexed individually.

Similarly, standard indexing is not helpful for binary XML storage. In both of these cases, indexing a database column using the standard sorts of index (B-tree, bitmap) is generally not helpful for accessing particular parts of an XML document.

[1] For `XMLType` data stored object-relationally, see "Indexing XMLType Data Stored Object-Relationally" on page 6-54. If your data is highly structured throughout, or your queries are not known at index creation time, then this approach might be appropriate.

XMLIndex provides a general, XML-specific index that indexes the internal structure of XML data. One of its main purposes is to overcome the indexing limitation presented by binary XML storage.

- An XMLIndex index with an *unstructured component* indexes the XML *tags* of your document and identifies document fragments based on XPath expressions that target them. It can also index scalar node *values*, to provide quick lookup based on individual values or ranges of values. It also records document *hierarchy* information for each node it indexes: relations parent–child, ancestor–descendant, and sibling. This index component is particularly useful for queries that extract XML fragments from documents that have little or variable structure.
- An XMLIndex index with a *structured component* indexes highly structured and predictable parts of XML data that is nevertheless for the most part unstructured. This index component is particularly useful for queries that project and use such islands of structured content.

See Also: "XMLIndex" on page 6-6

Oracle Text Indexes for XML Data

Besides accessing XML nodes such as elements and attributes, it is sometimes important to provide fast access to particular passages of text within XML text nodes. To query such full-text content within XML data, you can use XQuery Full Text (XQFT) or Oracle-specific full-text constructs. In either case, you create an appropriate Oracle Text (full-text) index. In the case of XQFT, the index is an XML search index, which is designed specifically for use with XMLType data stored as binary XML.

Full-text indexing is particularly useful for *document-centric* applications, which often contain a mix of XML elements and text-node content. Full-text searching can often be made more powerful, more focused, by combining it with structural XML searching, that is, by restricting it to certain parts of an XML document, which are identified by using XPath expressions.

See Also: "Indexing XML Data for Full-Text Queries" on page 6-48

Optimization Chooses the Right Indexes to Use

Which indexes are used when more than one might apply in a given case? Cost-based optimization determines the index or indexes to use, so that performance is maximized. Oracle Text indexes apply only to text, which, for XML data, means text nodes. Whenever text nodes are targeted and a corresponding Oracle Text index is defined, it is used. If other indexes are also appropriate in a particular context, then they can be used as well. However, just because an index is defined and it might appear applicable in a given situation does not mean that it will be used—it will not be used if the cost-based optimizer deems that its use is not cost-effective.

Function-Based Indexes Are Deprecated for XMLType

In releases prior to Oracle Database 11*g* Release 2 (11.2), function-based indexes were sometimes appropriate for use with XMLType data when an XPath expression targeted a singleton node. Oracle recommends that you use the structured component of XMLIndex instead. Doing so obviates the overhead associated with maintenance operations on function-based indexes, and it increases the number of situations in which the optimizer can correctly select the index. No changes to existing DML statements are required as a result of this.

It continues to be the case that, for object-relational storage of `XMLType`, defining an index for (deprecated) Oracle SQL function `extractValue` often leads, by XPath rewrite, to automatic creation of B-tree indexes on the underlying objects (instead of a function-based index on `extractValue`). The XPath target here must be a *singleton* element or attribute. A similar shortcut exists for `XMLCast` applied to `XMLQuery`.

See Also:

- "Indexing XMLType Data Stored Object-Relationally" on page 6-54
- "XMLIndex Structured Component" on page 6-8

XMLIndex

This section contains these topics:

B-tree indexes can be used advantageously with object-relational `XMLType` storage—they provide sharp focus by targeting the underlying objects directly. They are generally ineffective, however, in addressing the detailed structure (elements and attributes) of an XML document stored using binary XML. That is the special domain of `XMLIndex`.

Advantages of XMLIndex

`XMLIndex` is a *domain* index; it is designed specifically for the domain of XML data. It is a *logical* index. An `XMLIndex` index can be used for SQL/XML functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast`.

XMLIndex presents the following advantages over other indexing methods:

- An XMLIndex index is effective in any part of a query; it is not limited to use in a WHERE clause. This is not the case for any of the other kinds of indexes you might use with XML data.
- An XMLIndex index with an unstructured component can speed access to both SELECT list data and FROM list data, making it useful for XML *fragment* extraction, in particular. Function-based indexes, which are deprecated, cannot be used to extract document fragments.
- You can use an XMLIndex index with either XML schema-based or non-schema-based XMLType data stored as binary XML. B-tree indexing is appropriate only for XML schema-based data that is stored object-relationally.
- You can use an XMLIndex index for searches with XPath expressions that target *collections*, that is, nodes that occur multiple times within a document. This is not the case for function-based indexes.
- You need no prior knowledge of the XPath expressions that might be used in queries. The unstructured component of an XMLIndex index can be completely general. This is not the case for function-based indexes.
- If you have prior knowledge of the XPath expressions to be used in queries, then you can improve performance either by using a *structured* XMLIndex component that targets fixed, structured islands of data that are queried often.
- XMLIndex indexing—both index creation and index maintenance—can be carried out in parallel, using multiple database processes. This is not the case for function-based indexes, which are deprecated.

Structured and Unstructured XMLIndex Components

XMLIndex is used to index XML data that is unstructured or semi-structured, that is, data that generally has little or no fixed structure. It applies to XMLType data that is stored as binary XML.

Semi-structured XML data can sometimes nevertheless contain islands of predictable, structured data. An XMLIndex index can therefore have two components: a **structured component**, used to index such islands, and an **unstructured component**, used to index data that has little or variable structure.

A structured component can help with queries that project and use islands of structured content. A typical example is a free-form specification with fixed fields author, date, and title. An unstructured component can help with queries that extract XML fragments. Either component can be omitted from a given XMLIndex index.

Unlike a structured component, an unstructured component is general and relatively untargeted. It is appropriate for general indexing of document-centric XML data. A typical example is an XML web document or a book chapter.

You can create an XMLIndex index with both structured and unstructured components. A typical use case is supporting queries that extract an XML fragment from a document whenever some structured data is also present. The unstructured component is used for the fragment extraction. The structured component is used for a query predicate that checks for the structured data (for example, in the SQL WHERE clause).

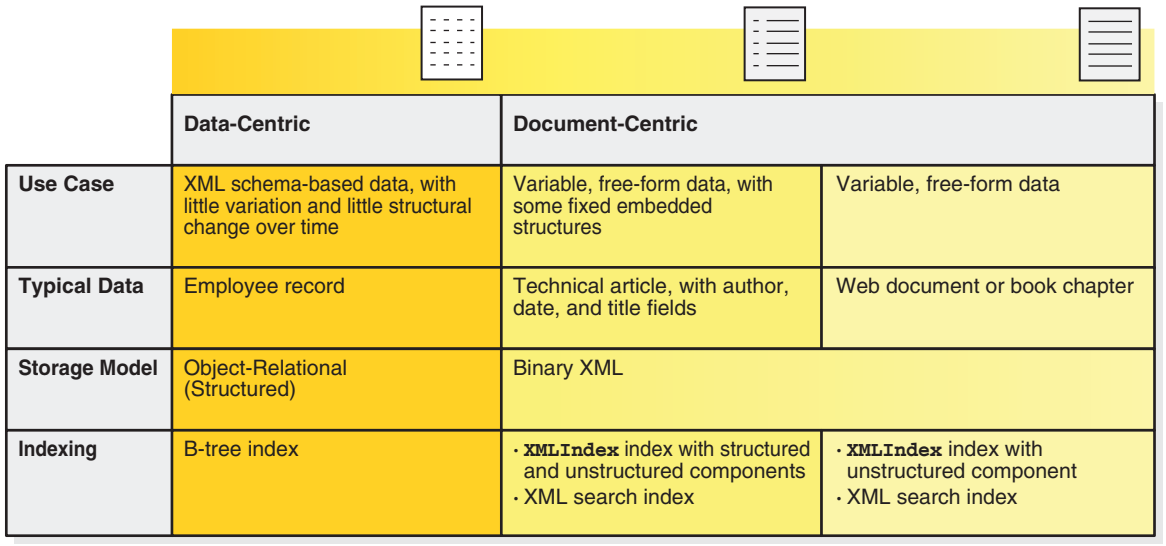
Though you can restrict an unstructured component to apply only to certain XPath subsets, its path table indexes node content that can be of different scalar types, which can require you to create multiple secondary indexes on the VALUE column to deal with the different data types—see "Secondary Indexes on Column VALUE" on page 6-16. Using an unstructured component alone can also lead to inefficiencies involving

multiple probes and self-joins of its path table, for queries that project structured islands.

On the other hand, a structured component is not suited for queries that involve little structure or queries that extract XML fragments. Use a structured component to index structured islands of data; use an unstructured component to index data that has little structure.

The last row indicates the applicability of `XMLIndex` for different XML data use cases. It shows that `XMLIndex` is appropriate for semi-structured XML data, however it is stored (last three columns). And an `XMLIndex` index with a structured component is useful for document-centric data that contains structured islands (fourth column).

Figure 6–1 XML Use Cases and XML Indexing



	Data-Centric	Document-Centric	
Use Case	XML schema-based data, with little variation and little structural change over time	Variable, free-form data, with some fixed embedded structures	Variable, free-form data
Typical Data	Employee record	Technical article, with author, date, and title fields	Web document or book chapter
Storage Model	Object-Relational (Structured)	Binary XML	
Indexing	B-tree index	· **`XMLIndex`** index with structured and unstructured components · XML search index	· **`XMLIndex`** index with unstructured component · XML search index

See Also:

- "XMLIndex Structured Component" on page 6-8
- "XMLIndex Unstructured Component" on page 6-12
- "Advantages of XMLIndex" on page 6-6 for a summary of the advantages provided by each `XMLIndex` component type

XMLIndex Structured Component

You create and use the structured component of an `XMLIndex` index for queries that project fixed, structured islands of XML content, even if the surrounding data is relatively unstructured.

A structured `XMLIndex` component organizes such islands in a *relational* format. In this it is similar to SQL/XML *function* `XMLTable`, and the syntax you use to define the structured component reflects this similarity. The relational tables used to store the indexing data are data-type aware, and each column can be of a different scalar data type.

You can thus think of the act of creating the structured component of an `XMLIndex` index as *decomposing* a structured portion of your XML data into relational format. This differs from the object-relational storage model of `XMLType` in these ways:

- A structured index component *explicitly* decomposes particular *portions* of your data, which you specify—portions that you commonly query. Object-relational `XMLType` storage involves automatic decomposition of an entire `XMLType` table or column.
- The structured component of an `XMLIndex` index applies to both XML schema-based and non-schema-based data. Object-relational `XMLType` storage applies only to data that is based on an XML schema.
- The decomposed data for a structured `XMLIndex` component is stored in addition to the `XMLType` data, as an index, rather than being the storage model for the `XMLType` data itself.
- For a structured `XMLIndex` component, the same data can be projected multiple times, as columns of different data type.

The index content tables used for the structured component of an `XMLIndex` index are part of the index, but because they are normal relational tables you can, in turn, *index* them using any standard relational indexes, including indexes that satisfy primary-key and foreign-key constraints. You can also index them using domain indexes, such as an Oracle Text `CONTEXT` index.

Another way to look at the structured component of an `XMLIndex` index sees that it acts as a *generalized function-based index*. A function-based index is similar to a structured `XMLIndex` component that has only one relational column.

If you find that for a particular application you are creating multiple function-based indexes, then consider using an `XMLIndex` index with a structured component instead. Create also B-tree indexes on the columns of the structured index component.

Note:

- Queries that use SQL/XML function `XMLTable` can typically be automatically rewritten to use the relational indexing tables of an `XMLIndex` structured component. In particular, this means that SQL `ORDER BY`, `GROUP BY`, and window constructs operating on columns of an `XMLTable` virtual table are rewritten to the same constructs operating on the real columns of the relational indexing tables of the structured `XMLIndex` component.

  The relational tables used for `XMLIndex` structured indexing also contain some internal, system-defined columns. These internal columns might change in the future, so do not write code that depends on any assumptions about their existence or contents.
- Queries that use Oracle SQL function `XMLSequence` within a SQL `TABLE` collection expression, that is, `TABLE (XMLSequence(...))`, are *not* rewritten to use the indexing tables of an `XMLIndex` structured component. Oracle SQL function `XMLSequence` is *deprecated* in Oracle Database 11*g* Release 2; use standard SQL/XML function `XMLTable` instead.

  See *Oracle Database SQL Language Reference* for information about the SQL `TABLE` collection expression.

See Also:

- "Using XMLIndex with a Structured Component" on page 6-22
- "SQL/XML Functions XMLQUERY, XMLTABLE, XMLExists, and XMLCast" on page 4-9
- "Function-Based Indexes Are Deprecated for XMLType" on page 6-5

Ignore the Index Content Tables; They Are Transparent

Although the index content tables of an `XMLIndex` structured component are normal relational tables, they are also *read-only*: you cannot add or drop their columns or modify (insert, update, or delete) their rows.

You can thus generally ignore the relational index content tables. You cannot access them, other than to `DESCRIBE` them and create (secondary) indexes on them. You need never explicitly gather statistics on them. You need only collect statistics on the `XMLIndex` index itself or the base table on which the `XMLIndex` index is defined; statistics are collected and maintained on the index content tables transparently.

See Also: "Collecting Statistics on XMLIndex Objects for the Cost-Based Optimizer" on page 6-39

Data Type Considerations for XMLIndex Structured Component

The relational tables that are used for an `XMLIndex` structured component use SQL data types. XQuery expressions that are used in queries use XML data types (XML Schema data types and XQuery data types).

XQuery typing rules can automatically change the data type of a subexpression, to ensure coherence and type-checking. For example, if a document that is queried using XPath expression `/PurchaseOrder/LineItem[@ItemNumber = 25]` is not XML schema-based, then the subexpression `@ItemNumber` is untyped, and it is then automatically cast to `xs:double` by the XQuery `=` comparison operator. To index this data using an `XMLIndex` structured component you must use `BINARY_DOUBLE` as the SQL data type.

This is a general rule. For an `XMLIndex` index with structured component to apply to a query, the data types must correspond. Table 6–5 shows the data-type correspondences.

Table 6–5 XML and SQL Data Type Correspondence for XMLIndex

XML Data Type	SQL Data Type
`xs:decimal`	`INTEGER` or `NUMBER`
`xs:double`	`BINARY_DOUBLE`
`xs:float`	`BINARY_FLOAT`
`xs:date`	`DATE`, `TIMESTAMP WITH TIMEZONE`
`xs:dateTime`	`TIMESTAMP`, `TIMESTAMP WITH TIMEZONE`
`xs:dayTimeDuration`	`INTERVAL DAY TO SECOND`
`xs:yearMonthDuration`	`INTERVAL YEAR TO MONTH`

> **Note:** If the XML data type is `xs:date` or `xs:dateTime`, and if you know that the data that you will query and for which you are creating an index will *not* contain a time-zone component, then you can increase performance by using SQL data type `DATE` or `TIMESTAMP`. If the data might contain a time-zone component, then you must use SQL data type `TIMESTAMP WITH TIMEZONE`.

If the XML and SQL data types involved do not have a built-in one-to-one correspondence, then you must make them correspond (according to Table 6–5), in order for the index to be picked up for your query. There are two ways you can do this:

- **Make the index correspond to the query –** Define (or redefine) the column in the structured index component, so that it corresponds to the XML data type. For example, if a query that you want to index uses the XML data type `xs:double`, then define the index to use the corresponding SQL data type, `BINARY_DOUBLE`.
- **Make the query correspond to the index –** In your query, explicitly cast the relevant parts of an XQuery expression to data types that correspond to the SQL data types used in the index content table.

Example 6–1 and Example 6–2 show how you can cast an XQuery expression in your query to match the SQL data type used in the index content table.

Example 6–1 Making Query Data Compatible with Index Data – SQL Cast

```
SELECT count(*) FROM purchaseorder
  WHERE XMLCast(XMLQuery('$p/PurchaseOrder/LineItem/@ItemNumber'
                         PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                 AS INTEGER)
        = 25;
```

Example 6–2 Making Query Data Compatible with Index Data – XQuery Cast

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/LineItem[xs:decimal(@ItemNumber) = 25]'
                  PASSING OBJECT_VALUE AS "p");
```

Notice that the number `25` plays a different role in these two examples, even though in both cases it is the purchase-order item number. In Example 6–1, `25` is a SQL number of data type `INTEGER`; in Example 6–2, `25` is an XQuery number of data type `xs:decimal`.

In Example 6–1, the `XMLQuery` result is cast to SQL type `INTEGER`, which is compared with the SQL value 25. In Example 6–2, the value of attribute `ItemNumber` is cast (in XQuery) to the XML data type `xs:decimal`, which is compared with the XQuery value 25 and which corresponds to the SQL data type (`INTEGER`) used for the index. There are thus two different kinds of data-type conversion in these examples, but they both convert query data to make it type-compatible with the index content table.

> **See Also:** "How to Map XML Schema Data Types to SQL Data Types" on page 18-17 for information about the built-in correspondence between XML Schema data types and SQL data types

Exchange Partitioning and XMLIndex

In exchange partitioning, you exchange a table with a partition of another table. The first table (call it *exchange_table*) must have the same structure as the partition (call it *partition*) of the second table (call it *table*) with which it will be exchanged.

In addition to having the same structure, the two tables must be similar with respect to indexing with an XMLIndex index. One of the following must be true:

- Neither has an XMLIndex index.
- Both have an XMLIndex index, and one of the following is true:
  - Neither index has a structured component.
  - Both indexes have a structured component.

If none of those conditions holds then you cannot perform exchange partitioning.

If both tables have an XMLIndex index with a structured component then you must perform some preprocessing before invoking ALTER TABLE EXCHANGE PARTITION, and you must perform some postprocessing after invoking it. Otherwise, the exchange-partition operation raises an error.

You use PL/SQL procedures exchangePreProc and exchangePostProc in package DBMS_XMLSTORAGE_MANAGE to perform this preprocessing and postprocessing, as illustrated in Example 6–3. Each of the XMLType tables, table and exchange_table, has an XMLIndex index that has a structured component.

Example 6–3 Exchange-Partitioning a Table Having an XMLIndex Structured Component

```
EXEC DBMS_XMLSTORAGE_MANAGE.exchangePreProc(USER, 'table');
EXEC DBMS_XMLSTORAGE_MANAGE.exchangePreProc(USER, 'exchange_table');

ALTER TABLE table EXCHANGE PARTITION partition WITH TABLE exchange_table
  WITH VALIDATION UPDATE INDEXES;

EXEC DBMS_XMLSTORAGE_MANAGE.exchangePostProc(USER, 'table');
EXEC DBMS_XMLSTORAGE_MANAGE.exchangePostProc(USER, 'exchange_table');
```

See Also:

- *Oracle Database SQL Language Reference*
- *Oracle Database Data Cartridge Developer's Guide* for general information about using ALTER TABLE EXCHANGE PARTITION with tables that have domain indexes (XMLIndex is a domain index)

XMLIndex Unstructured Component

Unlike a B-tree index, which you define for a specific database column that represents an individual XML element or attribute, or the XMLIndex structured component, which applies to specific, structured document parts, the unstructured component of an XMLIndex index is, by default, very general. Unless you specify a more narrow focus by detailing specific XPath expressions to use or not to use in indexing, an unstructured XMLIndex component applies to *all possible XPath expressions* for your XML data.

The unstructured component of an XMLIndex index has three logical parts:

- A **path index** – This indexes the XML *tags* of a document and identifies its various document *fragments*.

- An **order index** – This indexes the hierarchical *positions* of the nodes in an XML document. It keeps track of parent–child, ancestor–descendant, and sibling relations.
- A **value index** – This indexes the *values* of an XML document. It provides lookup by either value equality or value range. A value index is used for values in query predicates (`WHERE` clause).

The unstructured component of an `XMLIndex` index uses a path table and a set of (local) secondary indexes on the path table, which implement the logical parts described above. Two secondary indexes are created automatically:

- A **pikey index**, which implements the logical indexes for both path and order.
- A real **value index**, which implements the logical value index.

You can modify these two indexes or create additional secondary indexes. The path table and its secondary indexes are all owned by the owner of the base table upon which the `XMLIndex` index is created.

The pikey index handles paths and order relationships together, which gives the best performance in most cases. If you find in some particular case that the value index is not picked up when think it should be, you can replace the pikey index with separate indexes for the paths and order relationships. Such (optional) indexes are called **path id** and **order key** indexes, respectively. For best results, contact Oracle Support if you find that the pikey index is not sufficient for your needs in some case.

The path table contains one row for each indexed node in the XML document. For each indexed node, the **path table** stores:

- The corresponding *rowid* of the table that stores the document.
- A *locator*, which provides fast access to the corresponding document fragment. For binary XML storage of XML schema-based data, it also stores data-type information.
- An *order key*, to record the hierarchical position of the node in the document. You can think of this as a Dewey decimal key like that used in library cataloging and Internet protocol SNMP. In such a system, the key `3.21.5` represents the node position of the fifth child of the twenty-first child of the third child of the document root node.
- An identifier that represents an XPath *path* to the node.
- The effective *text value* of the node.

Table 6–6 shows the main information[2] that is in the path table.

Table 6–6 XMLIndex Path Table

Column	Data Type	Description
`PATHID`	`RAW(8)`	Unique identifier for the XPath path to the node.
`RID`	`ROWID`	Rowid of the table used to store the XML data.
`ORDER_KEY`	`RAW(1000)`	Decimal order key that identifies the hierarchical position of the node. (Document ordering is preserved.)
`LOCATOR`	`RAW(2000)`	Fragment-location information. Used for fragment extraction. For binary XML storage of XML schema-based data, data-type information is also stored here.

[2] The actual path table implementation may be slightly different.

Table 6–6 (Cont.) XMLIndex Path Table

Column	Data Type	Description
VALUE	VARCHAR2(4000)	Effective text value the node.

The pikey index uses path table columns PATHID, RID, and ORDER_KEY to represent the path and order indexes. An optional path id index uses columns PATHID and RID to represent the path index. A value index is an index on the VALUE column.

Example 6–4 explores the contents of the path table for two purchase-order documents.

Example 6–4 Path Table Contents for Two Purchase Orders

```
<PurchaseOrder>
 <Reference>SBELL-20021009123336O1PDT</Reference>
 <Actions>
  <Action>
   <User>SVOLLMAN</User>
  </Action>
 </Actions>
 . . .
</PurchaseOrder>

<PurchaseOrder>
 <Reference>ABEL-20021127121040897PST</Reference>
 <Actions>
  <Action>
   <User>ZLOTKEY</User>
  </Action>
  <Action>
   <User>KING</User>
  </Action>
 </Actions>
 . . .
</PurchaseOrder>
```

An XMLIndex index on an XMLType table or column storing these purchase orders includes a path table that has one row for each indexed node in the XML documents. Suppose that the system assigns the following PATHIDs when indexing the nodes according to their XPath expressions:

PATHID	Indexed XPath
1	/PurchaseOrder
2	/PurchaseOrder/Reference
3	/PurchaseOrder/Actions
4	/PurchaseOrder/Actions/Action
5	/PurchaseOrder/Actions/Action/User

The resulting path table would then be something like this (column LOCATOR is not shown):

PATHID	RID	ORDER_KEY	VALUE
1	R1	1	SBELL-20021009123336O1PDTSVOLLMAN

PATHID	RID	ORDER_KEY	VALUE
2	R1	1.1	SBELL-2002100912333601PDT
3	R1	1.2	SVOLLMAN
4	R1	1.2.1	SVOLLMAN
5	R1	1.2.1.1	SVOLLMAN
1	R2	1	ABEL-20021127121040897PSTZLOTKEYKING
2	R2	1.1	ABEL-20021127121040897PST
3	R2	1.2	ZLOTKEYKING
4	R2	1.2.1	ZLOTKEY
5	R2	1.2.1.1	ZLOTKEY
4	R2	1.2.2	KING
5	R2	1.2.2.1	KING

Ignore the Path Table – It Is Transparent

Though you can create secondary indexes on path-table columns, you can generally ignore the path table itself. You *cannot access* the path table, other than to `DESCRIBE` it and create (secondary) indexes on it. You need never explicitly gather statistics on the path table. You need only collect statistics on the `XMLIndex` index or the base table on which the `XMLIndex` index is defined; statistics are collected and maintained on the path table and its secondary indexes transparently.

> **See Also:** "Collecting Statistics on XMLIndex Objects for the Cost-Based Optimizer" on page 6-39

Column VALUE of an XMLIndex Path Table

A secondary index on column `VALUE` is used with XPath expressions in a `WHERE` clause that have predicates involving string matches. For example:

```
/PurchaseOrder[Reference/text() = "SBELL-2002100912333601PDT"]
```

Column `VALUE` stores the **effective text value** of an element or an attribute node—comments and processing instructions are ignored during indexing.

- For an *attribute*, the effective text value is the attribute value.
- For a *simple* element (an element that has no children), the effective text value is the concatenation of all of the text nodes of the element.
- For a *complex* element (an element that has children), the effective text value is the concatenation of (1) the text nodes of the element itself and (2) the effective text values of all of its simple-element descendants. (This is a recursive definition.)

The effective text value is limited (truncated), however, to 4000 bytes for a simple element or attribute and to 80 bytes for a complex element.

Column `VALUE` is a fixed size, `VARCHAR2(4000)`. Any overflow (beyond 4000 bytes) during index creation or update is truncated.

In addition to the 4000-byte limit for column `VALUE`, there is a limit on the size of a key for the secondary index created on this column. This is the case for B-tree and function-based indexes as well; it is not an `XMLIndex` limitation. The index-key size limit is a function of the block size for your database. It is this limit that determines how much of `VALUE` is indexed.

Thus, only the first 4000 bytes of the effective text value are stored in column VALUE, and only the first *N* bytes of column VALUE are indexed, where *N* is the index-key size limit ($N < 4000$). Because of the index-key size limit, the index on column VALUE acts only as a *preliminary filter* for the effective text value.

For example, suppose that your database block size requires that the VALUE index be no larger than 800 bytes, so that only the first 800 bytes of the effective text value is indexed. The first 800 bytes of the effective text value is first tested, using XMLIndex, and only if that text prefix matches the query value is the rest of the effective text value tested.

The secondary index on column VALUE is an index on SQL function substr (substring equality), because that function is used to test the text prefix. This function-based index is created automatically as part of the implementation of XMLIndex for column VALUE.

For example, the XPath expression /PurchaseOrder[Reference/text() = :1] in a query WHERE clause might, in effect, be rewritten to a test something like this:

```
substr(VALUE, 1 800) = substr(:1, 1, 800) AND VALUE = :1;
```

This conjunction contains two parts, which are processed from left to right. The first test uses the index on function substr as a preliminary filter, to eliminate text whose first 800 bytes do not match the first 800 bytes of the value of bind variable :1.

Only the first test uses an index—the full value of column VALUE is not indexed. After preliminary filtering by the first test, the second test checks the entire effective text value—that is, the full value of column VALUE—for full equality with the value of :1. This check does not use an index.

Even if only the first 800 bytes of text is indexed, it is important for query performance that up to 4000 bytes be stored in column VALUE, because that provides quick, direct access to the data, instead of requiring, for example, extracting it from deep within a CLOB-instance XML document. If the effective text value is greater than 4000 bytes, then the second test in the WHERE-clause conjunction requires accessing the base-table data.

Note that neither the VALUE column 4000-byte limit nor the index-key size affect query results in any way; they can affect only performance.

> **Note:** Because of the possibility of the VALUE column being truncated, an Oracle Text CONTEXT index created on the VALUE column might return incorrect results.

As mentioned, XMLIndex can be used with XML schema-based data. If an XML schema specifies a defaultValue value for a given element or attribute, and a particular document does not specify a value for that element or attribute, then the defaultValue value is used for the VALUE column.

Secondary Indexes on Column VALUE

Even if you do not specify a secondary index for column VALUE when you create an XMLIndex index, a default secondary index is created on column VALUE. This default index has the default properties—in particular, it is an index for *text* (string-valued) data only.

You can, however, create a VALUE index of a different type. For example, you can create a number-valued index if that is appropriate for many of your queries. You can create multiple secondary indexes on the VALUE column. An index of a particular type is used

only when it is appropriate. For example, a number-valued index is used only when the VALUE column is a number; it is ignored for other values. Secondary indexes on path-table columns are treated like any other secondary indexes—you can alter them, drop them, mark them unusable, and so on.

See Also:

- "Using XMLIndex with an Unstructured Component" on page 6-18 for examples of creating secondary indexes on column VALUE
- "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 6-41 for the syntax of the PARAMETERS clause

XPath Expressions that Are Not Indexed by an XMLIndex Unstructured Component

The following types of XPath expressions are *not* indexed by XMLIndex:

- Applications of XPath functions, *except* ora:contains. In particular, user-defined XPath functions are *not* indexed.
- Axes other than child, descendant, and attribute, that is, axes parent, ancestor, following-sibling, preceding-sibling, following, preceding, and ancestor-or-self.
- Expressions using the union operator, | (vertical bar).

Creating, Dropping, Altering, and Examining an XMLIndex Index

You create an XMLIndex index by declaring the index type to be XDB.XMLIndex, as illustrated in Example 6–5.

Example 6–5 Creating an XMLIndex Index

```
CREATE INDEX po_xmlindex_ix ON po_binxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex;
```

This creates an XMLIndex index named po_xmlindex_ix on XMLType table po_binxml. The index has only an unstructured component, no structured component.

You specify inclusion of a *structured* component in an XMLIndex index by including a *structured_clause* in the PARAMETERS clause. You specify inclusion of an *unstructured* component by including a *path_table_clause* in the PARAMETERS clause.

You can do this when you create the XMLIndex index or when you modify it. If, as in Example 6–5, you specify neither a *structured_clause* nor a *path_table_clause*, then *only* an unstructured component is included.

If an XMLIndex index has both an unstructured and a structured component, then you can drop either of these components using ALTER INDEX.

See Also:

- "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 6-41
- "structured_clause ::=" on page 6-44
- "path_table_clause ::=" on page 6-43
- "drop_path_table_clause ::=" on page 6-43
- "alter_index_group_clause ::=" on page 6-45

You can obtain the name of an XMLIndex index on a particular XMLType table (or column), as shown in Example 6–6. You can also select INDEX_NAME from DBA_INDEXES or ALL_INDEXES, as appropriate.

Example 6–6 Obtaining the Name of an XMLIndex Index on a Particular Table

```
SELECT INDEX_NAME FROM USER_INDEXES
  WHERE TABLE_NAME = 'PO_BINXML' AND ITYP_NAME = 'XMLINDEX';

INDEX_NAME
---------------
PO_XMLINDEX_IX

1 row selected.
```

You rename or drop an XMLIndex index just as you would any other index, as illustrated in Example 6–7. This renaming changes the name of the XMLIndex index only. It does not change the name of the path table—you can rename the path table separately.

Example 6–7 Renaming and Dropping an XMLIndex Index

```
ALTER INDEX po_xmlindex_ix RENAME TO new_name_ix;

DROP INDEX new_name_ix;
```

Similarly, you can change other index properties using other ALTER INDEX options, such as REBUILD. XMLIndex is no different from other index types in this respect.

The RENAME clause of an ALTER INDEX statement for XMLIndex applies only to the XMLIndex index itself. To rename the path table and secondary indexes, you must determine the names of these objects and use appropriate ALTER TABLE or ALTER INDEX statements on them directly. Similarly, to retrieve the physical properties of the secondary indexes or alter them in any other way, you must obtain their names, as in Example 6–12.

> **See Also:** "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 6-41 for the syntax of the PARAMETERS clause

Using XMLIndex with an Unstructured Component

This section covers operations you can perform on an XMLIndex index that has an unstructured component (whether or not it also has a structured component)—see "XMLIndex Unstructured Component" on page 6-12.

To include an unstructured component in an XMLIndex index, you use a *path_table_clause* in the PARAMETERS clause when you create or modify the XMLIndex index—see "path_table_clause ::=" on page 6-43.

If you do not specify a *structured* component, then the index will have an unstructured component, even if you do not specify the path table. It is however generally a good idea to specify the path table, so that it has a recognizable, user-oriented name that you can refer to in other XMLIndex operations.

Example 6–8 shows how to name the path table ("my_path_table") when creating an XMLIndex index with an unstructured component.

Example 6–8 Naming the Path Table of an XMLIndex Index

```
CREATE INDEX po_xmlindex_ix ON po_binxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
```

```
  PARAMETERS ('PATH TABLE my_path_table');
```

If you do not name the path table then its name is generated by the system, using the index name you provide to CREATE INDEX as a base. Example 6–9 shows this for the XMLIndex index created in Example 6–5.

Example 6–9 Determining the System-Generated Name of an XMLIndex Path Table

```
SELECT PATH_TABLE_NAME FROM USER_XML_INDEXES
  WHERE TABLE_NAME = 'PO_BINXML' AND INDEX_NAME = 'PO_XMLINDEX_IX';

PATH_TABLE_NAME
------------------------------
SYS67567_PO_XMLINDE_PATH_TABLE

1 row selected.
```

By default, the storage options of a path table and its secondary indexes are derived from the storage properties of the base table on which the XMLIndex index is created. You can specify different storage options by using a PARAMETERS clause when you create the index, as shown in Example 6–10. The PARAMETERS clause of CREATE INDEX (and ALTER INDEX) must be between single quotation marks (').

> **See Also:** "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 6-41 for the syntax of the PARAMETERS clause

Example 6–10 Specifying Storage Options When Creating an XMLIndex Index

```
CREATE INDEX po_xmlindex_ix ON po_binxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS
    ('PATH TABLE po_path_table
      (PCTFREE 5 PCTUSED 90 INITRANS 5
       STORAGE (INITIAL 1k NEXT 2k MINEXTENTS 3 BUFFER_POOL KEEP)
       NOLOGGING ENABLE ROW MOVEMENT PARALLEL 3)
      PIKEY INDEX po_pikey_ix (LOGGING PCTFREE 1 INITRANS 3)
      VALUE INDEX po_value_ix (LOGGING PCTFREE 1 INITRANS 3)');
```

Because XMLIndex is a logical *domain* index, not a physical index, all physical attributes are either zero (0) or NULL.

If an XMLIndex index has both an unstructured and a structured component, then you can use ALTER INDEX to drop the unstructured component. To do this, you drop the path table. Example 6–11 illustrates this. (This assumes that you also have a structured component—Example 6–20 results in an index with both structured and unstructured components.)

Example 6–11 Dropping an XMLIndex Unstructured Component

```
ALTER INDEX po_xmlindex_ix PARAMETERS('DROP PATH TABLE');
```

Note that, in addition to specifying storage options for the path table, Example 6–10 names the secondary indexes on the path table.

Like the name of the path table, the names of the secondary indexes on the path-table columns are generated automatically using the index name as a base, unless you specify them in the PARAMETERS clause. Example 6–12 illustrates this, and shows how you can determine these names using public view USER_IND_COLUMNS. It also shows that the pikey index uses three columns.

Example 6–12 Determining the Names of the Secondary Indexes of an XMLIndex Index

```
SELECT INDEX_NAME, COLUMN_NAME, COLUMN_POSITION FROM USER_IND_COLUMNS
  WHERE TABLE_NAME IN (SELECT PATH_TABLE_NAME FROM USER_XML_INDEXES
                         WHERE INDEX_NAME = 'PO_XMLINDEX_IX')
  ORDER BY INDEX_NAME, COLUMN_NAME;

INDEX_NAME                     COLUMN_NAME  COLUMN_POSITION
------------------------------ ------------ ---------------
SYS67563_PO_XMLINDE_PIKEY_IX   ORDER_KEY                  3
SYS67563_PO_XMLINDE_PIKEY_IX   PATHID                     2
SYS67563_PO_XMLINDE_PIKEY_IX   RID                        1
SYS67563_PO_XMLINDE_VALUE_IX   SYS_NC00006$               1

4 rows selected.
```

> **See Also:** Example 6–18 on page 6-21 for a similar, but more complex example

Creating Additional Secondary Indexes on an XMLIndex Path Table

This section adds extra secondary indexes to the `XMLIndex` index created in Example 6–10.

You can create any number of additional secondary indexes on the `VALUE` column of the path table of an `XMLIndex` index. These can be of different types, including function-based indexes and Oracle Text indexes.

Whether or not a given index is used for a given element occurrence when processing a query is determined by whether it is of the appropriate type for that value and whether it is cost-effective to use it.

Example 6–13 creates a function-based index on column `VALUE` of the path table using SQL function `substr`. This might be useful if your queries often use `substr` applied to the text nodes of XML elements.

Example 6–13 Creating a Function-Based Index on Path-Table Column VALUE

```
CREATE INDEX fn_based_ix ON po_path_table (substr(VALUE, 1, 100));
```

If you have many elements whose text nodes represent numeric values, then it can make sense to create a numeric index on the column `VALUE`. However, doing so directly, in a manner analogous to Example 6–13, raises an ORA-01722 error (invalid number) if some of the element values are *not* numbers. This is illustrated in Example 6–14.

Example 6–14 Trying to Create a Numeric Index on Path-Table Column VALUE Directly

```
CREATE INDEX direct_num_ix ON po_path_table (to_binary_double(VALUE));
CREATE INDEX direct_num_ix ON po_path_table (to_binary_double(VALUE))
                                            *
ERROR at line 1:
ORA-01722: invalid number
```

What is needed is an index that is used for numeric-valued elements but is ignored for element occurrences that do not have numeric values. Procedure `createNumberIndex` of package `DBMS_XMLINDEX` exists specifically for this purpose. You pass it the names of the database schema, the `XMLIndex` index, and the numeric index to be created. Creation of a numeric index is illustrated in Example 6–15.

Example 6–15 Creating a Numeric Index on Column VALUE with Procedure createNumberIndex

```
CALL DBMS_XMLINDEX.createNumberIndex('OE', 'PO_XMLINDEX_IX', 'API_NUM_IX');
```

Note that because such an index is specifically designed to ignore elements that do not have numeric values, its use does not detect their presence. If there are non-numeric elements and, for whatever reason, the XMLIndex index is not used in some query, then an ORA-01722 error is raised. However, if the index is used, no such error is raised, because the index ignores non-numeric data. As always, the use of an index never changes the result set—it never gives you different results, but use of an index can prevent you from detecting erroneous data.

Creating a date-valued index is similar to creating a numeric index; you use procedure DBMS_XMLINDEX.createDateIndex. Example 6–16 shows this.

Example 6–16 Creating a Date Index on Column VALUE with Procedure createDateIndex

```
CALL DBMS_XMLINDEX.createDateIndex('OE', 'PO_XMLINDEX_IX', 'API_DATE_IX',
                                   'dateTime');
```

Example 6–17 creates an Oracle Text CONTEXT index on column VALUE. This is useful for full-text queries on text values of XML elements. XPath predicates that use XPath function ora:contains are rewritten to applications of Oracle SQL function contains on column VALUE. If a CONTEXT index is defined on column VALUE, then it is used during predicate evaluation. An Oracle Text index is independent of all other VALUE-column indexes.

Example 6–17 Creating an Oracle Text CONTEXT Index on Path-Table Column VALUE

```
CREATE INDEX po_otext_ix ON po_path_table (VALUE)
  INDEXTYPE IS CTXSYS.CONTEXT PARAMETERS('TRANSACTIONAL');
```

See Also:

- "Column VALUE of an XMLIndex Path Table" on page 6-15 for information about the possibility of an Oracle Text CONTEXT index created on the VALUE column returning incorrect results
- "Indexing XML Data for Full-Text Queries" on page 6-48
- "XPath Rewrite and CONTEXT Indexes" on page E-23 for information about parameter TRANSACTIONAL

The query in Example 6–18 shows all of the secondary indexes created on the path table of an XMLIndex index. The indexes created explicitly are in bold. Note in particular that some indexes, such as the function-based index created on column VALUE, do not appear as such; the column name listed for such an index is a system-generated name such as SYS_NC00007$. You *cannot* see these columns by executing a query with COLUMN_NAME = 'VALUE' in the WHERE clause.

Example 6–18 Showing All Secondary Indexes on an XMLIndex Path Table

```
SELECT c.INDEX_NAME, c.COLUMN_NAME, c.COLUMN_POSITION, e.COLUMN_EXPRESSION
  FROM USER_IND_COLUMNS c LEFT OUTER JOIN USER_IND_EXPRESSIONS e
    ON (c.INDEX_NAME = e.INDEX_NAME)
  WHERE c.TABLE_NAME IN (SELECT PATH_TABLE_NAME FROM USER_XML_INDEXES
                         WHERE INDEX_NAME = 'PO_XMLINDEX_IX')
  ORDER BY c.INDEX_NAME, c.COLUMN_NAME;

INDEX_NAME           COLUMN_NAME  COLUMN_POSITION COLUMN_EXPRESSION
```

```
------------------- ------------ -------------- ---------------------
API_DATE_IX         SYS_NC00009$               1 SYS_EXTRACT_UTC(SYS_XMLCONV("V
                                                 ALUE",3,8,0,0,181))
API_NUM_IX          SYS_NC00008$               1 TO_BINARY_DOUBLE("VALUE")
FN_BASED_IX         SYS_NC00007$               1 SUBSTR("VALUE",1,100)
PO_OTEXT_IX         VALUE                      1
PO_PIKEY_IX         ORDER_KEY                  3
PO_PIKEY_IX         PATHID                     2
PO_PIKEY_IX         RID                        1
PO_VALUE_IX         SYS_NC00006$               1 SUBSTRB("VALUE",1,1599)

8 rows selected.
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information on PL/SQL procedures `createNumberIndex` and `createDateIndex` in package `DBMS_XMLINDEX`
- Appendix E, "Full-Text Search over XML Data Without XQuery" for information on using Oracle Text indexes

Using XMLIndex with a Structured Component

To include a structured component in an `XMLIndex` index, you use a *`structured_clause`* in the `PARAMETERS` clause when you create or modify the `XMLIndex` index—see "structured_clause ::=" on page 6-44.

A *`structured_clause`* specifies the structured islands that you want to index. You use the keyword `GROUP` to specify each structured island: an island thus corresponds syntactically to a structure **group**. If you specify no group explicitly, then the predefined group `DEFAULT_GROUP` is used. For `ALTER INDEX`, you precede the `GROUP` keyword with the modification operation keyword: `ADD_GROUP` specifies a new group (island); `DROP_GROUP` deletes a group.

Why have multiple groups within a single index, instead of simply using multiple `XMLIndex` indexes? The reason is that `XMLIndex` is a domain index, and you can create only one domain index of a given type on a given database column.

The syntax for defining a structure group, that is, indexing a structured island, is similar to the syntax for invoking SQL/XML *function* `XMLTable`: you use keywords `XMLTable` and `COLUMNS` to define relational columns, and you use multilevel chaining of `XMLTable` to handle collections. To simplify the creation of such an index, you can use PL/SQL function `DBMS_XMLSTORAGE_MANAGE.getSIDXDefFromView` to provide exactly the `XMLTable` expression needed for creating the index.

See Also:

- "Indexing Binary XML Data Exposed Using a Relational View" on page 9-3 for information about using `DBMS_XMLSTORAGE_MANAGE.getSIDXDefFromView`
- Example 6–27, "Using a Structured XMLIndex Component for a Query with Two Predicates" on page 6-30
- "Indexing XML Data for Full-Text Queries" on page 6-48
- "Using a Registered PARAMETERS Clause for XMLIndex" on page 6-41
- "structured_clause ::=" on page 6-44
- "Usage of XMLIndex_xmltable_clause" on page 6-48 for information about an `XMLType` column in an `XMLTable` clause
- "Usage of column_clause" on page 6-48 for information about keywords `COLUMNS` and `VIRTUAL`
- "Data Type Considerations for XMLIndex Structured Component" on page 6-10

Using Namespaces and Storage Clauses with an XMLIndex Structured Component

Example 6–19 shows the creation of an `XMLIndex` index that has only a structured component (no path table clause) and that uses the `XMLNAMESPACES` clause to specify namespaces. It specifies that the index data be compressed and use tablespace `SYSAUX`. The example assumes a binary XML table `po_binxml` with non XML schema-based data.

Example 6–19 XMLIndex with Only a Structured Component and Using Namespaces

```
CREATE INDEX po_struct ON po_binxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('XMLTable po_ptab
                (TABLESPACE "SYSAUX" COMPRESS FOR OLTP)
                XMLNAMESPACES (DEFAULT ''http://www.example.com/po''),
                ''/purchaseOrder''
                COLUMNS orderdate   DATE          PATH ''@orderDate'',
                        id          BINARY_DOUBLE PATH ''@id'',
                        items       XMLType       PATH ''items/item'' VIRTUAL
              XMLTable li_tab
                (TABLESPACE "SYSAUX" COMPRESS FOR OLTP)
                XMLNAMESPACES (DEFAULT ''http://www.example.com/po''),
                ''/item'' PASSING items
                COLUMNS partnum     VARCHAR2(15)  PATH ''@partNum'',
                        description CLOB          PATH ''productName'',
                        usprice     BINARY_DOUBLE PATH ''USPrice'',
                        shipdat     DATE          PATH ''shipDate''');
```

Each of the `TABLESPACE` clauses in Example 6–19 applies at the table level (tables `po_ptab` and `li_tab`). You can also specify `TABLESPACE` clauses for a given `XMLIndex` index or a given partition.

Adding a Structured Component to an XMLIndex Index

Example 6–20 shows the creation of an `XMLIndex` index with only an unstructured component. An unstructured component is created because the `PARAMETERS` clause explicitly names the path table.

Example 6–20 then uses ALTER INDEX to add a structured component (group) named po_item. This structure group includes two relational tables, each specified with keyword XMLTable.

Example 6–20 XMLIndex Index: Adding a Structured Component

```
CREATE INDEX po_xmlindex_ix ON po_binxml (OBJECT_VALUE)
  INDEXTYPE IS XDB.XMLIndex PARAMETERS ('PATH TABLE path_tab');

BEGIN
  DBMS_XMLINDEX.registerParameter(
    'myparam',
    'ADD_GROUP GROUP po_item
       XMLTable po_idx_tab ''/PurchaseOrder''
         COLUMNS reference   VARCHAR2(30)  PATH ''Reference'',
                 requestor   VARCHAR2(30)  PATH ''Requestor'',
                 username    VARCHAR2(30)  PATH ''User'',
                 lineitem    XMLType       PATH ''LineItems/LineItem'' VIRTUAL
       XMLTable po_index_lineitem ''/LineItem'' PASSING lineitem
         COLUMNS itemno      BINARY_DOUBLE PATH ''@ItemNumber'',
                 description VARCHAR2(256) PATH ''Description'',
                 partno      VARCHAR2(14)  PATH ''Part/@Id'',
                 quantity    BINARY_DOUBLE PATH ''Part/@Quantity'',
                 unitprice   BINARY_DOUBLE PATH ''Part/@UnitPrice''');
END;
/

ALTER INDEX po_xmlindex_ix PARAMETERS('PARAM myparam');
```

The top-level table, po_idx_tab, has columns reference, requestor, username, and lineitem. Column lineitem is of type XMLType. It represents a collection, so it is passed to the second XMLTable construct to form the second-level relational table, po_index_lineitem, which has columns itemno, description, partno, quantity, and unitprice.

The keyword VIRTUAL is *required* for an XMLType column. It specifies that the XMLType column itself is not materialized: its data is stored in the XMLIndex index only in the form of the relational columns specified by its corresponding XMLTable table.

You cannot create more than one XMLType column in a given XMLTable clause. To achieve that effect, you must instead define an additional group.

Example 6–20 also illustrates the use of a registered parameter string in the PARAMETERS clause. It uses PL/SQL procedure DBMS_XMLINDEX.registerParameter to register the parameters string named myparam. Then it uses ALTER INDEX to update the index parameters to include those in the string myparam.

Using Non-Blocking ALTER INDEX with an XMLIndex Structured Component

When you use ALTER INDEX to add a group or a column for the structured component of an XMLIndex index, this index-maintenance operation obtains an exclusive DDL lock on the base table and the index.

The base table is locked to DML operations, and the index cannot be used for queries until the ALTER INDEX operation is finished. This means that during this index maintenance the index cannot be used by other sessions that query or perform DML operations on the base table. The duration of the ALTER INDEX operation and the attendant locking depends on the volume of data in the base XMLType column.

You can avoid or work around this problem as follows:

1. Use keyword **NONBLOCKING** before ADD_GROUP or ADD_COLUMN in the PARAMETERS clause of the ALTER INDEX statement that creates the structured-component group or column.

   This updates the index as needed, but it does not index any base-table data. Because it does not depend on the base-table data it is quick regardless of the base-table size.

2. Invoke PL/SQL procedure DBMS_XMLINDEX.**process_pending**.

   This procedure indexes rows of the base table and populates tables of the index, just as if keyword NONBLOCKING were absent. However, in this case only a few rows are locked at a time while they are processed and the changes committed. Rows that have already been locked for some other purpose are skipped. This can significantly reduce lock contention and allow indexing of some rows to proceed at the same time as querying or DML on other rows.

   When procedure process_pending finishes it returns, as OUT parameters:

   - The number of rows that it could not index. This is either because they were *locked* for another purpose or because an error was raised (this number includes the number returned as the other OUT parameter).

     After you think those locks have been removed, invoke procedure process_pending again to try to process those pending rows.

   - The number of rows that it could not index because an *error* was raised. (This should be rare.)

     Check table SYS_AIXSXI_*index_number*_ERRORTAB for information about those errors, then take action to fix the underlying problems. *index_number* is the object number of the index.

   Repeat step 2 as many times as necessary until procedure process_pending indicates that all rows have been successfully indexed or you encounter an insurmountable problem and decide to cancel the indexing operation altogether.

   You can cancel the indexing at any time (before step 3) by using keywords **NONBLOCKING ABORT** in the PARAMETERS clause of a separate ALTER INDEX statement for the same XMLIndex index.

3. If all rows have been successfully indexed then use keywords **NONBLOCKING COMPLETE** in the PARAMETERS clause of a separate ALTER INDEX statement for the same XMLIndex index.

Example 6–21 illustrates this.

Example 6–21 Using DBMS_XMLINDEX.PROCESS_PENDING To Index XML Data

```
CREATE INDEX po_struct ON po_binxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('XMLTable po_idx_tab
                ''/PurchaseOrder''
                COLUMNS reference   VARCHAR2(30)  PATH ''Reference'',
                        requestor   VARCHAR2(30)  PATH ''Requestor'',
                        username    VARCHAR2(30)  PATH ''User'',
                        lineitem    XMLType       PATH ''LineItems/LineItem'' VIRTUAL
              XMLTable po_index_lineitem
                ''/LineItem'' PASSING lineitem
                COLUMNS itemno      BINARY_DOUBLE PATH ''@ItemNumber'',
                        description VARCHAR2(256) PATH ''Description'',
                        partno      VARCHAR2(14)  PATH ''Part/@Id'',
                        quantity    BINARY_DOUBLE PATH ''Part/@Quantity'',
                        unitprice   BINARY_DOUBLE PATH ''Part/@UnitPrice''');
```

```
ALTER INDEX po_struct
  PARAMETERS('NONBLOCKING ADD_GROUP GROUP po_action_group
              XMLTABLE po_idx_tab
                ''/PurchaseOrder''
                COLUMNS actions       XMLType       PATH  ''Actions/Action'' VIRTUAL
              XMLTABLE po_idx_action
                ''/Action'' PASSING actions
                COLUMNS actioned_by   VARCHAR2(10)  PATH  ''User'',
                        date_actioned TIMESTAMP     PATH  ''Date''');

DECLARE
  num_pending NUMBER := 0;
  num_errored NUMBER := 0;
BEGIN
 DBMS_XMLINDEX.process_pending('oe', 'po_struct', num_pending, num_errored);
 DBMS_OUTPUT.put_line('Number of rows still pending = ' || num_pending);
 DBMS_OUTPUT.put_line('Number of rows with errors   = ' || num_errored);
END;
/
Number of rows still pending = 0
Number of rows with errors   = 0

PL/SQL procedure successfully completed.

ALTER INDEX po_struct PARAMETERS('NONBLOCKING COMPLETE');
```

Just as table SYS_AIXSXI_*index_number*_**ERRORTAB** reports errors, so table SYS_AIXSXI_*index_number*_**PENDINGTAB** records the current status of each base-table row: whether or not it has been indexed. A row might not yet be indexed because it is locked by for some other purpose or because trying to index it raised an error. In the latter case, consult SYS_AIXSXI_*index_number*_ERRORTAB for specific information about the error.

See Also: "alter_index_group_clause ::=" on page 6-45

Modifying the Data Type of a Structured XMLIndex Component

If an error is raised because some of your data does not match the data type used for the corresponding column of the structured XMLIndex component, you can in some cases simply modify the index by passing keyword MODIFY_COLUMN_TYPE to ALTER INDEX. You can, for example, expand a VARCHAR2(30) column to, say, VARCHAR2(40) if it needs to accommodate data that is up to 40 characters. This is simpler and more efficient than dropping the column and then adding a new column. The new data type must be compatible with the old one: the same restrictions apply as apply for ALTER TABLE MODIFY COLUMN.

See Also:

- *Oracle Database SQL Language Reference* for information about ALTER TABLE MODIFY COLUMN
- "modify_column_type_clause :==" on page 6-46

Dropping an XMLIndex Structured Component

If an XMLIndex index has both an unstructured and a structured component, then you can use ALTER INDEX to drop the structured component. You do this by dropping *all* of the structure groups that compose the structured component. Example 6–22 shows how to drop the structured component that was added in Example 6–20, by dropping its only structure group, po_item.

Example 6–22 Dropping an XMLIndex Structured Component

```
ALTER INDEX po_xmlindex_ix PARAMETERS('DROP_GROUP GROUP po_item');
```

Indexing the Relational Tables of a Structured XMLIndex Component

As indicated in section "XMLIndex Structured Component" on page 6-8, because the tables used for the structured component of an `XMLIndex` index are normal relational tables, you can index them using any standard relational indexes.

Example 6–23 illustrates this. It creates a B-tree index on the `reference` column of the index content table (structured fragment) for the `XMLIndex` index of Example 6–20.

Example 6–23 Creating a B-tree Index on an XMLIndex Index Content Table

```
CREATE INDEX idx_tab_ref_ix ON po_idx_tab (reference);
```

How to Tell Whether XMLIndex is Used

It is at query compile time that Oracle Database determines whether or not a given `XMLIndex` index can be used, that is, whether the query can be rewritten into a query against the index.

For an unstructured `XMLIndex` component, if it cannot be determined at compile time that an XPath expression in the query is a subset of the paths you specified to be used for `XMLIndex` indexing, then the unstructured component of the index is not used.

For example, if the path `/PurchaseOrder/LineItems//*` is included for indexing, then a query with `/PurchaseOrder/LineItems/LineItem/Description` can use the index, but a query with `//Description` cannot. The latter also matches potential `Description` elements that are not children of `/PurchaseOrder/LineItems`, and it is not possible at compile time to know if such additional `Description` elements are present in the data.

To know whether a particular `XMLIndex` index has been used in resolving a query, you can examine an execution plan for the query.

- If the *unstructured* component of the index is used, then its path table, order key, or path id is referenced in the execution plan. The execution plan does *not* directly indicate that a domain index was used; it does *not* refer to the `XMLIndex` index by name. See Example 6–24 on page 6-27 and Example 6–26 on page 6-29.
- If the *structured* component of the index is used, then one or more of its index content tables is called out in the execution plan. See Example 6–27 on page 6-30 and Example 6–28 on page 6-31.

See Also:

- *Oracle Database SQL Language Reference*
- *Oracle Database SQL Tuning Guide*

Example 6–24 shows that the `XMLIndex` index created in Example 6–8 is used in a particular query. The reference to `MY_PATH_TABLE` in the execution plan here indicates that the `XMLIndex` index (created in Example 6–8) is used in this query. Similarly, reference to columns `LOCATOR`, `ORDER_KEY`, and `PATHID` indicates the same thing.

Example 6–24 Checking Whether an XMLIndex Unstructured Component Is Used

```
SET AUTOTRACE ON EXPLAIN

SELECT XMLQuery('/PurchaseOrder/Requestor' PASSING OBJECT_VALUE RETURNING CONTENT) FROM po_binxml
```

```
  WHERE XMLExists('/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]' PASSING OBJECT_VALUE);

XMLQUERY('/PURCHASEORDER/REQUESTOR'PASSINGOBJECT_VALUERETURNINGCONTENT)
--------------------------------------------------------------------
<Requestor>Sarah J. Bell</Requestor>

1 row selected.


Execution Plan
. . .
-----------------------------------------------------------------------------------------------------------------
| Id  | Operation                     | Name                          | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |                               |     1 |    24 |    28   (4)| 00:00:01 |
|   1 |  SORT GROUP BY                |                               |     1 |  3524 |            |          |
|*  2 |   TABLE ACCESS BY INDEX ROWID | MY_PATH_TABLE                 |     2 |  7048 |     3   (0)| 00:00:01 |
|*  3 |    INDEX RANGE SCAN           | SYS67616_PO_XMLINDE_PIKEY_IX  |     1 |       |     2   (0)| 00:00:01 |
|   4 |  NESTED LOOPS                 |                               |     1 |    24 |    28   (4)| 00:00:01 |
|   5 |   VIEW                        | VW_SQ_1                       |     1 |    12 |    26   (0)| 00:00:01 |
|   6 |    HASH UNIQUE                |                               |     1 |  5046 |            |          |
|   7 |     NESTED LOOPS              |                               |     1 |  5046 |    26   (0)| 00:00:01 |
|*  8 |      TABLE ACCESS BY INDEX ROWID| MY_PATH_TABLE               |     1 |  3524 |    24   (0)| 00:00:01 |
|*  9 |       INDEX RANGE SCAN        | SYS67616_PO_XMLINDE_VALUE_IX  |    73 |       |     1   (0)| 00:00:01 |
|* 10 |      TABLE ACCESS BY INDEX ROWID| MY_PATH_TABLE               |     1 |  1522 |     2   (0)| 00:00:01 |
|* 11 |       INDEX RANGE SCAN        | SYS67616_PO_XMLINDE_PIKEY_IX  |     1 |       |     1   (0)| 00:00:01 |
|  12 |   TABLE ACCESS BY USER ROWID  | PO_BINXML                     |     1 |    12 |     1   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - filter(SYS_XMLI_LOC_ISNODE("SYS_P0"."LOCATOR")=1)
   3 - access("SYS_P0"."RID"=:B1 AND "SYS_P0"."PATHID"=HEXTORAW('76E2') )
   8 - filter("SYS_P4"."VALUE"='SBELL-20021009123336O1PDT' AND "SYS_P4"."PATHID"=HEXTORAW('4F8C')  AND
              SYS_XMLI_LOC_ISNODE("SYS_P4"."LOCATOR")=1)
   9 - access(SUBSTRB("VALUE",1,1599)='SBELL-20021009123336O1PDT')
  10 - filter(SYS_XMLI_LOC_ISNODE("SYS_P2"."LOCATOR")=1)
  11 - access("SYS_P4"."RID"="SYS_P2"."RID" AND "SYS_P2"."PATHID"=HEXTORAW('4E36')  AND
              "SYS_P2"."ORDER_KEY"<"SYS_P4"."ORDER_KEY")
       filter("SYS_P4"."ORDER_KEY"<SYS_ORDERKEY_MAXCHILD("SYS_P2"."ORDER_KEY") AND
              SYS_ORDERKEY_DEPTH("SYS_P2"."ORDER_KEY")+1=SYS_ORDERKEY_DEPTH("SYS_P4"."ORDER_KEY"))
. . .
```

Given the name of a path table from an execution plan such as this, you can obtain the name of its `XMLIndex` index as shown in Example 6–25. (This is more or less opposite to the query in Example 6–9.)

Example 6–25 Obtaining the Name of an XMLIndex Index from Its Path-Table Name

```
SELECT INDEX_NAME FROM USER_XML_INDEXES WHERE PATH_TABLE_NAME = 'MY_PATH_TABLE';

INDEX_NAME
------------------------------
PO_XMLINDEX_IX

1 row selected.
```

`XMLIndex` can be used for XPath expressions in the `SELECT` list, the `FROM` list, and the `WHERE` clause of a query, and it is useful for SQL/XML functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast`. Unlike function-based indexes, which are deprecated for `XMLType`, `XMLIndex` indexes can be used when you extract data from an XML fragment in a document.

Example 6–26 illustrates this.

Example 6–26 Extracting Data from an XML Fragment Using XMLIndex

```
SET AUTOTRACE ON EXPLAIN

SELECT li.description, li.itemno
  FROM po_binxml, XMLTable('/PurchaseOrder/LineItems/LineItem'
                           PASSING OBJECT_VALUE
                           COLUMNS "DESCRIPTION" VARCHAR(40) PATH 'Description',
                                   "ITEMNO"      INTEGER     PATH '@ItemNumber') li
  WHERE XMLExists('/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE);

DESCRIPTION                                ITEMNO
---------------------------------------- ----------
A Night to Remember                               1
The Unbearable Lightness Of Being                 2
Sisters                                           3

3 rows selected.

Execution Plan

----------------------------------------------------------------------------------------------------------------------
| Id  | Operation                      | Name                          | Rows  | Bytes |Cost (%CPU)| Time     |
----------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT               |                               |     1 |  1546 |   30   (4)|00:00:01 |
|*  1 |  FILTER                        |                               |       |       |           |         |
|
|*  2 |   TABLE ACCESS BY INDEX ROWID  | MY_PATH_TABLE                 |     1 |  3524 |    3   (0)|00:00:01 |
|*  3 |    INDEX RANGE SCAN            | SYS67616_PO_XMLINDE_PIKEY_IX  |     1 |       |    2   (0)|00:00:01 |
|*  4 |  FILTER                        |                               |       |       |           |         |
|*  5 |   TABLE ACCESS BY INDEX ROWID  | MY_PATH_TABLE                 |     1 |  3524 |    3   (0)|00:00:01 |
|*  6 |    INDEX RANGE SCAN            | SYS67616_PO_XMLINDE_PIKEY_IX  |     1 |       |    2   (0)|00:00:01 |
|   7 |  NESTED LOOPS                  |                               |       |       |           |         |
|   8 |   NESTED LOOPS                 |                               |     1 |  1546 |   30   (4)|00:00:01 |
|   9 |    NESTED LOOPS                |                               |     1 |    24 |   28   (4)|00:00:01 |
|  10 |     VIEW                       | VW_SQ_1                       |     1 |    12 |   26   (0)|00:00:01 |
|  11 |      HASH UNIQUE               |                               |     1 |  5046 |           |         |
|  12 |       NESTED LOOPS             |                               |     1 |  5046 |   26   (0)|00:00:01 |
|* 13 |        TABLE ACCESS BY INDEX ROWID| MY_PATH_TABLE              |     1 |  3524 |   24   (0)|00:00:01 |
|* 14 |         INDEX RANGE SCAN       | SYS67616_PO_XMLINDE_VALUE_IX  |    73 |       |    1   (0)|00:00:01 |
|* 15 |        TABLE ACCESS BY INDEX ROWID| MY_PATH_TABLE              |     1 |  1522 |    2   (0)|00:00:01 |
|* 16 |         INDEX RANGE SCAN       | SYS67616_PO_XMLINDE_PIKEY_IX  |     1 |       |    1   (0)|00:00:01 |
|  17 |     TABLE ACCESS BY USER ROWID | PO_BINXML                     |     1 |    12 |    1   (0)|00:00:01 |
|* 18 |    INDEX RANGE SCAN            | SYS67616_PO_XMLINDE_PIKEY_IX  |     1 |       |    1   (0)|00:00:01 |
|* 19 |   TABLE ACCESS BY INDEX ROWID  | MY_PATH_TABLE                 |     1 |  1522 |    2   (0)|00:00:01 |
----------------------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter(:B1<SYS_ORDERKEY_MAXCHILD(:B2))
   2 - filter(SYS_XMLI_LOC_ISNODE("SYS_P2"."LOCATOR")=1)
   3 - access("SYS_P2"."RID"=:B1 AND "SYS_P2"."PATHID"=HEXTORAW('28EC')  AND "SYS_P2"."ORDER_KEY">:B2 AND
              "SYS_P2"."ORDER_KEY"<SYS_ORDERKEY_MAXCHILD(:B3))
       filter(SYS_ORDERKEY_DEPTH("SYS_P2"."ORDER_KEY")=SYS_ORDERKEY_DEPTH(:B1)+1)
   4 - filter(:B1<SYS_ORDERKEY_MAXCHILD(:B2))
   5 - filter(SYS_XMLI_LOC_ISNODE("SYS_P5"."LOCATOR")=1)
   6 - access("SYS_P5"."RID"=:B1 AND "SYS_P5"."PATHID"=HEXTORAW('60E0')  AND "SYS_P5"."ORDER_KEY">:B2 AND
              "SYS_P5"."ORDER_KEY"<SYS_ORDERKEY_MAXCHILD(:B3))
       filter(SYS_ORDERKEY_DEPTH("SYS_P5"."ORDER_KEY")=SYS_ORDERKEY_DEPTH(:B1)+1)
  13 - filter("SYS_P10"."VALUE"='SBELL-2002100912333601PDT' AND "SYS_P10"."PATHID"=HEXTORAW('4F8C')  AND
```

```
              SYS_XMLI_LOC_ISNODE("SYS_P10"."LOCATOR")=1)
  14 - access(SUBSTRB("VALUE",1,1599)='SBELL-20021009123336O1PDT')
  15 - filter(SYS_XMLI_LOC_ISNODE("SYS_P8"."LOCATOR")=1)
  16 - access("SYS_P10"."RID"="SYS_P8"."RID" AND "SYS_P8"."PATHID"=HEXTORAW('4E36')  AND
              "SYS_P8"."ORDER_KEY"<"SYS_P10"."ORDER_KEY")
       filter("SYS_P10"."ORDER_KEY"<SYS_ORDERKEY_MAXCHILD("SYS_P8"."ORDER_KEY") AND
              SYS_ORDERKEY_DEPTH("SYS_P8"."ORDER_KEY")+1=SYS_ORDERKEY_DEPTH("SYS_P10"."ORDER_KEY"))
  18 - access("PO_BINXML".ROWID="SYS_ALIAS_4"."RID" AND "SYS_ALIAS_4"."PATHID"=HEXTORAW('3748') )
  19 - filter(SYS_XMLI_LOC_ISNODE("SYS_ALIAS_4"."LOCATOR")=1)

Note
-----
   - dynamic sampling used for this statement (level=2)
```

The execution plan for the query in Example 6–26 shows, by referring to the path table, that `XMLIndex` is used. It also shows the use of Oracle internal SQL function `sys_orderkey_depth`—see "Guidelines for Using XMLIndex with an Unstructured Component" on page 6-34.

Example 6–27 shows an execution plan that indicates that the `XMLIndex` index created in Example 6–20 is picked up for a query that uses two `WHERE` clause predicates. It is the same query as in Example 6–43, and the same XML search index is in effect, as is also shown in the execution plan.

Example 6–27 Using a Structured XMLIndex Component for a Query with Two Predicates

```
EXPLAIN PLAN FOR
  SELECT XMLQuery('/PurchaseOrder/LineItems/LineItem'
                  PASSING OBJECT_VALUE RETURNING CONTENT)
    FROM po_binxml
    WHERE XMLExists('/PurchaseOrder/LineItems/LineItem
                     [Description contains text "Picnic"]'
                    PASSING OBJECT_VALUE)
      AND XMLExists('/PurchaseOrder[User="SBELL"]' PASSING OBJECT_VALUE);

Explained.

-----------------------------------------------------------------------------------------------------------------
| Id  | Operation                           | Name                          |Rows|Bytes| Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                    |                               |   1| 2051|     9   (0)| 00:00:01 |
|   1 |  SORT GROUP BY                      |                               |   1| 3524|            |          |
|*  2 |   TABLE ACCESS BY INDEX ROWID BATCHED| PATH_TAB                      |   2| 7048|     3   (0)| 00:00:01 |
|*  3 |    INDEX RANGE SCAN                 | SYS86751_PO_XMLINDE_PIKEY_IX |   1|     |     2   (0)| 00:00:01 |
|   4 |  NESTED LOOPS SEMI                  |                               |   1| 2051|     6   (0)| 00:00:01 |
|   5 |   TABLE ACCESS BY INDEX ROWID       | PO_BINXML                     |   1| 2024|     4   (0)| 00:00:01 |
|*  6 |    DOMAIN INDEX                     | PO_CTX_IDX                    |    |     |     4   (0)| 00:00:01 |
|*  7 |   TABLE ACCESS BY INDEX ROWID BATCHED| PO_IDX_TAB                    |  13|  351|     2   (0)| 00:00:01 |
|*  8 |    INDEX RANGE SCAN                 | SYS86751_86755_OID_IDX        |   1|     |     1   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - filter(SYS_XMLI_LOC_ISNODE("SYS_P1"."LOCATOR")=1)
   3 - access("SYS_P1"."RID"=:B1 AND "SYS_P1"."PATHID"=HEXTORAW('3748') )
   6 - access("CTXSYS"."CONTAINS"(SYS_MAKEXML(0,"XMLDATA"),'<query><textquery grammar="CONTEXT"
              lang="english">{Picnic} INPATH
              (/PurchaseOrder/LineItems/LineItem/Description)</textquery><xquery><offset>0</
              offset></xquery></query>')>0)
   7 - filter("SYS_SXI_0"."USERNAME"='SBELL')
   8 - access("PO_BINXML"."SYS_NC_OID$"="SYS_SXI_0"."OID")

Note
```

```
-----
   - dynamic sampling used for this statement (level=2)

30 rows selected.
```

With only the unstructured XMLIndex component, the query would have involved a join of the path table to itself, because of the two different paths in the WHERE clause.

The presence in Example 6–27 of the path table name, path_tab, indicates that the unstructured component of the index is used. The presence of the index content table po_idx_tab indicates that the structured index component is used. The presence of the XML search index, po_ctx_idx, indicates that it too is used.

Example 6–28 shows an execution plan that indicates that the same XMLIndex index is also picked up for a query that uses multilevel XMLTable chaining. With only the unstructured XMLIndex component, this query too would involve a join of the path table to itself, because of the different paths in the two XMLTable function calls.

Example 6–28 Using a Structured XMLIndex Component for a Query with Multilevel Chaining

```
EXPLAIN PLAN FOR
  SELECT po.reference, li.*
    FROM po_binxml p,
         XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                  COLUMNS reference   VARCHAR2(30)  PATH 'Reference',
                          lineitem    XMLType       PATH 'LineItems/LineItem') po,
         XMLTable('/LineItem' PASSING po.lineitem
                  COLUMNS itemno      BINARY_DOUBLE PATH '@ItemNumber',
                          description VARCHAR2(256) PATH 'Description',
                          partno      VARCHAR2(14)  PATH 'Part/@Id',
                          quantity    BINARY_DOUBLE PATH 'Part/@Quantity',
                          unitprice   BINARY_DOUBLE PATH 'Part/@UnitPrice') li
    WHERE po.reference = 'SBELL-20021009123335280PDT';

-----------------------------------------------------------------------------------------------------
| Id  | Operation                    | Name                  | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |                       |    17 | 20366 |     8   (0)| 00:00:01 |
|   1 |  NESTED LOOPS                |                       |       |       |            |          |
|   2 |   NESTED LOOPS               |                       |    17 | 20366 |     8   (0)| 00:00:01 |
|   3 |    NESTED LOOPS              |                       |     1 |   539 |     3   (0)| 00:00:01 |
|*  4 |     TABLE ACCESS FULL        | PO_IDX_TAB            |     1 |   529 |     3   (0)| 00:00:01 |
|*  5 |     INDEX UNIQUE SCAN        | SYS_C007442           |     1 |    10 |     0   (0)| 00:00:01 |
|*  6 |    INDEX RANGE SCAN          | SYS86751_86759_PKY_IDX|    17 |       |     1   (0)| 00:00:01 |
|   7 |   TABLE ACCESS BY INDEX ROWID| PO_INDEX_LINEITEM     |    17 | 11203 |     5   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   4 - filter("SYS_SXI_2"."REFERENCE"='SBELL-20021009123335280PDT')
   5 - access("P"."SYS_NC_OID$"="SYS_SXI_2"."OID")
   6 - access("SYS_SXI_2"."KEY"="SYS_SXI_3"."PKEY")

Note
-----
   - dynamic sampling used for this statement

25 rows selected.
```

The execution plan shows direct access to the relational index content tables, po_idx_tab and po_index_lineitem. There is *no* access at all to the path table, path_tab.

See Also: "Collecting Statistics on XMLIndex Objects for the Cost-Based Optimizer" on page 6-39

Turning Off Use of XMLIndex

You can turn off the use of XMLIndex in any of these ways:

- Use optimizer hint /*+ NO_XML_QUERY_REWRITE */
- Use optimizer hint /*+ NO_XMLINDEX_REWRITE */

Hints NO_XML_QUERY_REWRITE and NO_XMLINDEX_REWRITE turn off the use of *all* XMLIndex indexes. In addition to turning off use of XMLIndex, NO_XML_QUERY_REWRITE turns off all XQuery optimization (XMLIndex is part of XPath rewrite).

Example 6–29 shows the use of these optimizer hints.

Example 6–29 Turning Off XMLIndex Using Optimizer Hints

```
SELECT /*+ NO_XMLINDEX_REWRITE */
  count(*) FROM po_binxml WHERE XMLExists('$p/*' PASSING OBJECT_VALUE AS "p");

SELECT /*+ NO_XML_QUERY_REWRITE */
  count(*) FROM po_binxml WHERE XMLExists('$p/*' PASSING OBJECT_VALUE AS "p");
```

Note: The NO_INDEX optimizer hint does not apply to XMLIndex.

See Also: "XQuery Optional Features" on page 4-26 for information about XQuery pragmas ora:no_xmlquery_rewrite and ora:xmlquery_rewrite, which you can use for fine-grained control of XQuery optimization

XMLIndex Path Subsetting: Specifying the Paths You Want to Index

One of the advantages of an XMLIndex index with an unstructured component is that it is very general: you need not specify which XPath locations to index; you need no prior knowledge of the XPath expressions that will be queried. By default, an unstructured XMLIndex component indexes all possible XPath locations in your XML data.

However, if you are aware of the XPath expressions that you are most likely to query, then you can narrow the focus of XMLIndex indexing and thus improve performance. Having fewer indexed nodes means less space is required for indexing, which improves index maintenance during DML operations. Having fewer indexed nodes improves DDL performance, and having a smaller path table improves query performance.

You narrow the focus of indexing by pruning the set of XPath expressions (paths) corresponding to XML fragments to be indexed, specifying a subset of all possible paths. You can do this in two alternative ways:

- Exclusion – Start with the default behavior of including all possible XPath expressions, and exclude some of them from indexing.
- Inclusion – Start with an empty set of XPath expressions to be used in indexing, and add paths to this inclusion set.

You can specify path subsetting either when you create an XMLIndex index using CREATE INDEX or when you modify it using ALTER INDEX. In both cases, you provide the subsetting information in the PATHS parameter of the statement's PARAMETERS clause. For exclusion, you use keyword EXCLUDE. For inclusion, you use keyword INCLUDE for ALTER INDEX and no keyword for CREATE INDEX (list the paths to include). You can also specify namespace mappings for the nodes targeted by the PATHS parameter.

For ALTER INDEX, keyword INCLUDE or EXCLUDE is followed by keyword ADD or REMOVE, to indicate whether the list of paths that follows the keyword is to be added or removed from the inclusion or exclusion list. For example, this statement adds path /PurchaseOrder/Reference to the list of paths to be excluded from indexing:

```
ALTER INDEX po_xmlindex_ix REBUILD
  PARAMETERS ('PATHS (EXCLUDE ADD (/PurchaseOrder/Reference))');
```

To alter an XMLIndex index so that it *includes all* possible paths, use keyword INDEX_ALL_PATHS. See "alter_index_paths_clause ::=" on page 6-42.

Note: If you create an XMLIndex index that has both structured and unstructured components, then, by default, any nodes indexed in the structured component are also indexed in the unstructured component; that is, they are *not* automatically *excluded* from the unstructured component. If you do not want unstructured XMLIndex indexing to apply to them, then you must explicitly use path subsetting to exclude them.

See Also: "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 6-41 for the syntax of the PARAMETERS clause

Examples of XMLIndex Path Subsetting

This section presents some examples of defining XMLIndex indexes on subsets of XPath expressions.

Example 6–30 XMLIndex Path Subsetting with CREATE INDEX

```
CREATE INDEX po_xmlindex_ix ON po_binxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('PATHS (INCLUDE (/PurchaseOrder/LineItems//*
                               /PurchaseOrder/Reference))');
```

This statement creates an index that indexes only top-level element PurchaseOrder and some of its children, as follows:

- All LineItems elements and their descendants
- All Reference elements

It does that by including the specified paths, starting with an empty set of paths to be used for the index.

Example 6–31 XMLIndex Path Subsetting with ALTER INDEX

```
ALTER INDEX po_xmlindex_ix REBUILD
  PARAMETERS ('PATHS (INCLUDE ADD (/PurchaseOrder/Requestor
                                   /PurchaseOrder/Actions/Action//*))');
```

This statement adds two more paths to those used for indexing. These paths index element `Requestor` and descendants of element `Action` (and their ancestors).

Example 6–32 XMLIndex Path Subsetting Using a Namespace Prefix

If an XPath expression to be used for `XMLIndex` indexing uses namespace prefixes, you can use a `NAMESPACE MAPPING` clause to the `PATHS` list, to specify those prefixes. Here is an example:

```
CREATE INDEX po_xmlindex_ix ON po_binxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('PATHS (INCLUDE (/PurchaseOrder/LineItems//*   /PurchaseOrder/ipo:Reference)
                   NAMESPACE MAPPING (xmlns="http://xmlns.oracle.com"
                                      xmlns:ipo="http://xmlns.oracle.com/ipo"))');
```

XMLIndex Path-Subsetting Rules

The following rules apply to `XMLIndex` path subsetting:

- The paths must reference only child and descendant axes, and they must test only element and attribute nodes or their names (possibly using wildcards). In particular, the paths must not involve predicates.
- You cannot specify both path exclusion and path inclusion; choose one or the other.
- If an index was created using path exclusion (inclusion), then you can modify it using only path exclusion (inclusion)—index modification must either further restrict or further extend the path subset. For example, you cannot create an index that includes certain paths and subsequently modify it to exclude certain paths.

Guidelines for Using XMLIndex with an Unstructured Component

The following are some guidelines for using `XMLIndex` with an unstructured component. These guidelines are applicable only when the two alternatives discussed return the same result set.

- Avoid prefixing `//` with ancestor elements. For example, use `//c`, *not* **`/a/b`**`//c`, provided these return the same result set.
- Avoid prefixing `/*` with ancestor elements. For example, use `/*/*/*`, *not* **`/a`**`/*/*`, provided these return the same result set.
- In a `WHERE` clause, use `XMLExists` rather than `XMLCast` of `XMLQuery`. This can allow optimization that, in effect, invokes a subquery against the path-table `VALUE` column. For example, use this:

  ```
  SELECT count(*) FROM purchaseorder p
    WHERE
      XMLExists('$p/PurchaseOrder/LineItems/LineItem/Part[@Id="715515011020"]'
                    PASSING OBJECT_VALUE AS "p");
  ```

  Do not use this:

  ```
  SELECT count(*) FROM purchaseorder p
    WHERE XMLCast(XMLQuery('$p/PurchaseOrder/LineItems/LineItem/Part/@Id'
                           PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                    AS VARCHAR2(14))
          = "715515011020";
  ```

- When possible, use `count(*)`, *not* `count(XMLCast(XMLQuery(...))`, in a `SELECT` clause. For example, if you know that a `LineItem` element in a purchase-order document has only one `Description` child, use this:

```
SELECT count(*) FROM po_binxml, XMLTable('//LineItem' PASSING OBJECT_VALUE);
```

Do not use this:

```
SELECT count(li.value)
 FROM po_binxml p, XMLTable('//LineItem' PASSING p.OBJECT_VALUE
                            COLUMNS value VARCHAR2(30) PATH 'Description') li;
```

- Reduce the number of XPath expressions used in a query `FROM` list as much as possible. For example, use this:

```
SELECT li.description
  FROM po_binxml p,
       XMLTable('PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE
                COLUMNS description VARCHAR2(256) PATH 'Description') li;
```

Do not use this:

```
SELECT li.description
  FROM po_binxml p,
       XMLTable('PurchaseOrder/LineItems' PASSING p.OBJECT_VALUE) ls,
       XMLTable('LineItems/LineItem'      PASSING ls.OBJECT_VALUE
                COLUMNS description VARCHAR2(256) PATH 'Description') li;
```

- If you use an XPath expression in a query to drill down inside a virtual table (created, for example, using SQL/XML function `XMLTable`), then create a secondary index on the order key of the path table using Oracle SQL function `sys_orderkey_depth`. Here is an example of such a query; the selection navigates to element `Description` inside virtual line-item table `li`.

```
SELECT li.description
  FROM po_binxml p,
       XMLTable('PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE
                COLUMNS description VARCHAR2(256) PATH 'Description') li;
```

Such queries are evaluated using function `sys_orderkey_depth`, which returns the depth of the order-key value. Because the order index uses two columns, the index needed is a *composite* index over columns `ORDER_KEY` and `RID`, as well as over function `sys_orderkey_depth` applied to the `ORDER_KEY` value. For example:

```
CREATE INDEX depth_ix ON my_path_table
  (RID, sys_orderkey_depth(ORDER_KEY), ORDER_KEY);
```

See Also: Example 6–26 on page 6-29 for an example that shows the use of `sys_orderkey_depth`

Guidelines for Using XMLIndex with a Structured Component

The following are some guidelines for using `XMLIndex` with a structured component.

- Use `XMLIndex` with a structured component to project and index XML data as relational columns. Do not use function-based indexes; they are deprecated for use with XML. See "Function-Based Indexes Are Deprecated for XMLType" on page 6-5.
- Ensure data type correspondence between a query and an `XMLIndex` index that has a structured component. See "Data Type Considerations for XMLIndex Structured Component" on page 6-10.
- If you create a relational view over `XMLType` data (for example, using SQL function `XMLTable`), then consider also creating an `XMLIndex` index with a structured component that targets the same relational columns. See Chapter 9, "Relational

Views over XML Data".

- Instead of using a single XQuery expression for both fragment extraction and value filtering (search), use SQL/XML function `XMLQuery` in the `SELECT` clause to extract fragments and `XMLExists` in the `WHERE` clause to filter values.

  This lets Oracle XML DB evaluate fragment extraction functionally or by using streaming evaluation. For value filtering, this lets Oracle XML DB pick up an `XMLIndex` index that has a relevant structured component.

- To order query results, use a SQL `ORDER BY` clause, together with SQL/XML function `XMLTable`. Avoid using the XQuery `order by` clause. This is particularly pertinent if you use an `XMLIndex` index with a structured component.

XMLIndex Partitioning and Parallelism

If you partition an `XMLType` table, or a table with an `XMLType` column, using range, list, or hash partitioning, you can also create an `XMLIndex` index on the table. If you use the keyword `LOCAL` when you create the `XMLIndex` index, then the index and all of its storage tables are locally equipartitioned with respect to the base table.

If you do not use the keyword `LOCAL`, then you cannot create an `XMLIndex` index on a partitioned table. Also, if you composite-partition a table, then you cannot create an `XMLIndex` index on it.

You can use a `PARALLEL` clause (with optional degree) when creating or altering an `XMLIndex` index to ensure that index creation and maintenance are carried out in parallel. If the base table is partitioned or enabled for parallelism, then this can improve the performance for both DML operations (`INSERT`, `UPDATE`, `DELETE`) and index DDL operations (`CREATE`, `ALTER`, `REBUILD`).

Specifying parallelism for an index can also consume more storage, because storage parameters apply separately to each query server process. For example, an index created with an `INITIAL` value of 5M and a parallelism degree of 12 consumes at least 60M of storage during index creation.

The syntax for the parallelism clause for `CREATE INDEX` and `ALTER INDEX` is the same as for other domain indexes:

```
{ NOPARALLEL | PARALLEL [ integer ] }
```

Example 6–33 creates an `XMLIndex` index with a parallelism degree of 10. If the base table is partitioned, then this index is equipartitioned.

Example 6–33 Creating an XMLIndex Index in Parallel

```
CREATE INDEX po_xmlindex_ix ON sale_info (sale_po_clob) INDEXTYPE IS XDB.XMLIndex
  LOCAL PARALLEL 10;
```

In Example 6–33, the path table and the secondary indexes are created with the same parallelism degree as the `XMLIndex` index itself, 10, by inheritance. You can specify different parallelism degrees for these by using separate `PARALLEL` clauses. Example 6–34 demonstrates this. Again, because of keyword `LOCAL`, if the base table is partitioned, then this index is equipartitioned.

Example 6–34 Using Different PARALLEL Degrees for XMLIndex Internal Objects

```
CREATE INDEX po_xmlindex_ix ON sale_info (sale_po_clob) INDEXTYPE IS XDB.XMLIndex
  LOCAL NOPARALLEL PARAMETERS ('PATH TABLE po_path_table (PARALLEL 10)
                               PIKEY INDEX po_pikey_ix
                               VALUE INDEX po_value_ix (PARALLEL 5)');
```

In Example 6–34, the XMLIndex index itself is created serially, because of NOPARALLEL. The secondary index po_pikey_ix is also populated serially, because no parallelism is specified explicitly for it; it inherits the parallelism of the XMLIndex index. The path table itself is created with a parallelism degree of 10, and the secondary index value column, po_value_ix, is populated with a degree of 5, due to their explicit parallelism specifications.

Any parallelism you specify for an XMLIndex index, its path table, or its secondary indexes is exploited during subsequent DML operations and queries.

Note that there are two places where you can specify parallelism for XMLIndex: within the PARAMETERS clause parenthetical expression and after it.

See Also:

- *Oracle Database SQL Language Reference* for information on the CREATE INDEX parallel clause
- "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 6-41 for the syntax of the PARAMETERS clause
- "Structured and Unstructured XMLIndex Components" on page 6-7

Asynchronous (Deferred) Maintenance of XMLIndex Indexes

This feature applies to an XMLIndex index that has *only* an *unstructured* component. If you specify asynchronous maintenance for an XMLIndex index that has a *structured* component (even if it also has an unstructured component), then an error is raised.

By default, XMLIndex indexing is updated (maintained) at each DML operation, so that it remains in sync with the base table. In some situations, you might not require this, and using possibly stale indexes might be acceptable. In that use case, you can decide to defer the cost of index maintenance, performing at commit time only or at some time when database load is reduced. This can improve DML performance. It can also improve index maintenance performance by enabling bulk loading of unsynchronized index rows when an index is synchronized.

Using a stale index has no effect, other than performance, on DML operations. It can have an effect on query results, however: If the index is not up-to-date at query time, then the query results might not be up-to-date either. Even if only one column of a base table is of data type XMLType, all queries on that table reflect the database data as of the last synchronization of the XMLIndex index on the XMLType column.

You can specify index maintenance deferment using the parameters clause of a CREATE INDEX or ALTER INDEX statement.

Be aware that even if you defer synchronization for an XMLIndex index, the following database operations automatically synchronize the index:

- Any DDL operation on the index – ALTER INDEX or creation of secondary indexes
- Any DDL operation on the base table – ALTER TABLE or creation of another index

Table 6–7 lists the synchronization options and the ASYNC clause syntax you use to specify them. The ASYNC clause is used in the PARAMETERS clause of a CREATE INDEX or ALTER INDEX statement for XMLIndex.

Table 6–7 Index Synchronization

When to Synchronize	ASYNC Clause Syntax
Always	`ASYNC (SYNC ALWAYS)` This is the default behavior. You can specify it explicitly, to cancel a previous `ASYNC` specification.
Upon commit	`ASYNC (SYNC ON COMMIT)`
Periodically	`ASYNC (SYNC EVERY "repeat_interval")` *repeat_interval* is the same as for the calendaring syntax of `DBMS_SCHEDULER` To use `EVERY`, you must have the `CREATE JOB` privilege.
Manually, on demand	`ASYNC (SYNC MANUAL)` You can manually synchronize the index using PL/SQL procedure `DBMS_XMLINDEX.syncIndex`.

Optional `ASYNC` syntax parameter `STALE` is intended for possible future use; you need never specify it explicitly. It has value `FALSE` whenever `ALWAYS` is used; otherwise it has value `TRUE`. Specifying an explicit `STALE` value that contradicts this rule raises an error.

Example 6–35 creates an XMLIndex index that is synchronized every Monday at 3:00 pm, starting tomorrow.

Example 6–35 Specifying Deferred Synchronization for XMLIndex

```
CREATE INDEX po_xmlindex_ix ON po_binxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('ASYNC (SYNC EVERY "FREQ=HOURLY; INTERVAL = 1")');
```

Example 6–36 manually synchronizes the index created in Example 6–35.

Example 6–36 Manually Synchronizing an XMLIndex Index Using SYNCINDEX

```
EXEC DBMS_XMLINDEX.syncIndex('OE', 'PO_XMLINDEX_IX', REINDEX => TRUE);
```

When `XMLIndex` index synchronization is deferred, all DML changes (inserts, updates, and deletions) made to the base table since the last index synchronization are recorded in a pending table, one row per DML operation. The name of this table is the value of column `PEND_TABLE_NAME` of static public views `USER_XML_INDEXES`, `ALL_XML_INDEXES`, and `DBA_XML_INDEXES`.

You can examine this table to determine when synchronization might be appropriate for a given `XMLIndex` index. The more rows there are in the pending table, the more the index is likely to be in need of synchronization.

If the pending table is large, then setting parameter `REINDEX` to `TRUE` when calling `syncIndex`, as in Example 6–36, can improve performance. When `REINDEX` is `TRUE`, all of the secondary indexes are dropped and then re-created after the pending table data is bulk-loaded.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference*, section "Calendaring Syntax", for the syntax of *repeat_interval*
- *Oracle Database PL/SQL Packages and Types Reference* for information on PL/SQL procedure `DBMS_XMLINDEX.syncIndex`

Syncing an XMLIndex Index in Case of Error ORA-08181

If a query raises error ORA-08181 in the following situation, check whether the base XMLType table of the query has an XMLIndex index with an unstructured component. If so, then manually synchronize the XMLIndex index using DBMS_XMLINDEX.syncIndex.

1. In a pluggable database, *PDB1*, you created an XMLType table or column *XTABCOL*, which you indexed using an XMLIndex index that has an unstructured component.
2. You plugged *PDB1* into a container database.
3. You cloned *PDB1* to a new pluggable database, *PDB2*.
4. Error ORA-08181 is raised when you query *XTABCOL* in *PDB2*.

If the error is raised still after synchronizing then seek another cause. Error ORA-08181 is a general error that can be raised in various situations, of which this is only one.

> **See Also:** "Oracle XML DB and Database Consolidation" on page 35-12

Collecting Statistics on XMLIndex Objects for the Cost-Based Optimizer

The Oracle Database cost-based optimizer determines how to most cost-effectively evaluate a given query, including which indexes, if any, to use. For it to be able to do this accurately, you must collect statistics on various database objects.

> **Note:** The following applies only to procedures in package DBMS_STATS; it does not apply to ANALYZE INDEX.

For XMLIndex, you normally need to collect statistics on only the base table on which the XMLIndex index is defined (using, for example, procedure DBMS_STATS.gather_table_stats). This automatically collects statistics for the XMLIndex index itself, as well as the path table, its secondary indexes, and any structured component content tables and their secondary indexes.

If you delete statistics on the base table (using procedure DBMS_STATS.delete_table_stats), then statistics on the other objects are also deleted. Similarly, if you collect statistics on the XMLIndex index (using procedure DBMS_STATS.gather_index_stats), then statistics are also collected on the path table, its secondary indexes, and any structured component content tables and their secondary indexes.

Example 6–37 collects statistics on the base table po_binxml. Statistics are automatically collected on the XMLIndex index, its path table, and the secondary path-table indexes.

Example 6–37 Automatic Collection of Statistics on XMLIndex Objects

```
CALL DBMS_STATS.gather_table_stats(USER, 'PO_BINXML', ESTIMATE_PERCENT => NULL);
```

> **See Also:** "Data Dictionary Static Public Views Related to XMLIndex" on page 6-39 for information about database views that record statistics information for an XMLIndex index

Data Dictionary Static Public Views Related to XMLIndex

Information about the standard database indexes is available in static public views USER_INDEXES, ALL_INDEXES, and DBA_INDEXES. Similar information about XMLIndex

indexes is available in static public views USER_XML_INDEXES, ALL_XML_INDEXES, and DBA_XML_INDEXES.

Table 6–8 describes the columns in each of these views.

Table 6–8 XMLIndex Static Public Views

Column Name	Type	Description
ASYNC	VARCHAR2	Asynchronous index updating specification. See "Asynchronous (Deferred) Maintenance of XMLIndex Indexes" on page 6-37.
EX_OR_INCLUDE	VARCHAR2	Path subsetting: ■ FULLY_IX – The index uses no path subsetting. ■ EXCLUDE – The index uses only exclusion subsetting. ■ INCLUDE – The index uses only inclusion subsetting.
INDEX_NAME	VARCHAR2	Name of the XMLIndex index.
INDEX_OWNER	VARCHAR2	Owner of the index. Not available for USER_XML_INDEXES.
INDEX_TYPE	VARCHAR2	The types of components the index is composed of: STRUCTURED, UNSTRUCTURED, or STRUCTURED AND UNSTRUCTURED.
PARAMETERS	XMLType	Information from the PARAMETERS clause that was used to create the index. If an unstructured XMLIndex component is present, the PARAMETERS clause can include the set of XPath paths defining path-subsetting and the name of a scheduler job for synchronization. If a structured component is present, the PARAMETERS clause includes the name of the structure group and the table definitions provided by XMLTable, including the XQuery expressions that define the columns.
PATH_TABLE_NAME	VARCHAR2	Name of the XMLIndex path table.
PEND_TABLE_NAME	VARCHAR2	Name of the table that records base-table DML operations since the last index synchronization. See "Asynchronous (Deferred) Maintenance of XMLIndex Indexes" on page 6-37.
TABLE_NAME	VARCHAR2	Name of the base table on which the index is defined.
TABLE_OWNER	VARCHAR2	Owner of the base table on which the index is defined.

These views provide information about an XMLIndex index, but there is no single static data dictionary view that provides information about the statistics gathered for an XMLIndex index. This statistics information is distributed among the following views:

- USER_INDEXES, ALL_INDEXES, DBA_INDEXES – Column LAST_ANALYZED provides the date when the XMLIndex index was last analyzed.
- USER_TAB_STATISTICS, ALL_TAB_STATISTICS, DBA_TAB_STATISTICS – Column TABLE_NAME provides information about the structured and unstructured components of an XMLIndex index. For information about the structured or unstructured component, query using the name of the path table or the XMLTable table as TABLE_NAME, respectively.
- USER_IND_STATISTICS, ALL_IND_STATISTICS, DBA_IND_STATISTICS – Column INDEX_NAME provides information about each of the secondary indexes for an

XMLIndex index. for information about a given secondary index, query using the name of that secondary index as INDEX_NAME.

PARAMETERS Clause for CREATE INDEX and ALTER INDEX

This section describes the usage and syntax of the PARAMETERS clause for SQL statements CREATE INDEX and ALTER INDEX when used with XMLIndex.

See Also:

- *Oracle Database SQL Language Reference* for the syntax of *index_attributes*
- *Oracle Database SQL Language Reference* for the syntax of *segment_attributes_clause*
- *Oracle Database SQL Language Reference* for the syntax of *table_properties*
- *Oracle Database SQL Language Reference* for the syntax of *parallel_clause*
- *Oracle Database SQL Language Reference* for additional information about the syntax and semantics of CREATE INDEX
- *Oracle Database SQL Language Reference* for additional information about the syntax and semantics of ALTER INDEX
- *Oracle Database PL/SQL Packages and Types Reference*, section "Calendaring Syntax", for the syntax of *repeat_interval*

Using a Registered PARAMETERS Clause for XMLIndex

The string value used for the PARAMETERS clause of a CREATE INDEX or ALTER INDEX statement has a 1000-character limit. To get around this limitation, you can use PL/SQL procedures registerParameter and modifyParameter in package DBMS_XMLINDEX.

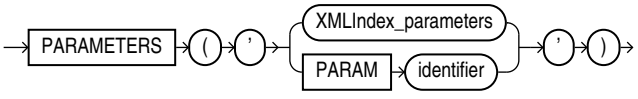
For each of these procedures, you provide a string of parameters (unlimited in length) and an identifier under which the string is registered. Then, in the index PARAMETERS clause, you provide the identifier preceded by the keyword PARAM, instead of a literal string.

The identifier must already have been registered before you can use it in a CREATE INDEX or ALTER INDEX statement.

See Also: Example 6–20 on page 6-24

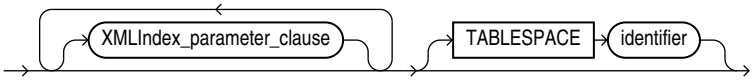
PARAMETERS Clause Syntax for CREATE INDEX and ALTER INDEX

XMLIndex_parameters_clause ::=



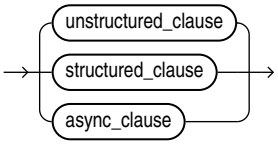
See Also: "Usage of XMLIndex_parameters_clause" on page 6-46

XMLIndex_parameters ::=

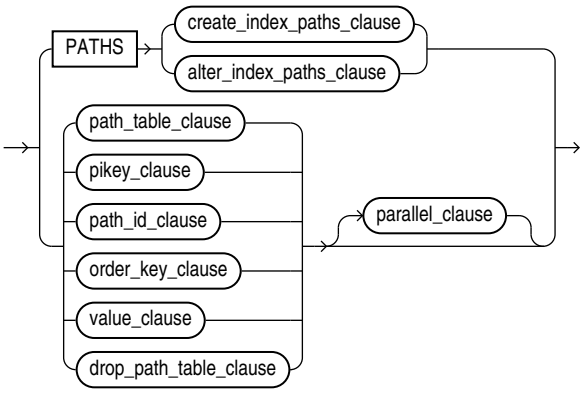


See Also: "Usage of XMLIndex_parameters" on page 6-46

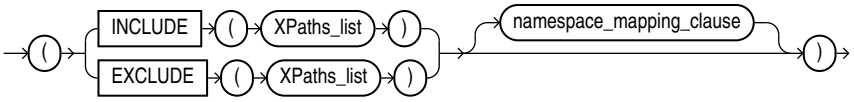
XMLIndex_parameter_clause ::=



unstructured_clause ::=



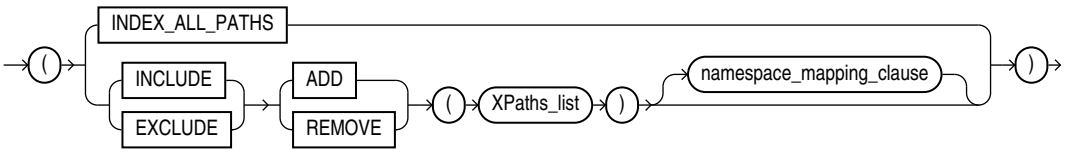
create_index_paths_clause ::=



See Also:

- "Usage of PATHS Clause" on page 6-46
- "Usage of create_index_paths_clause and alter_index_paths_clause" on page 6-47

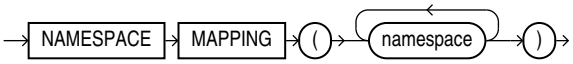
alter_index_paths_clause ::=



See Also:

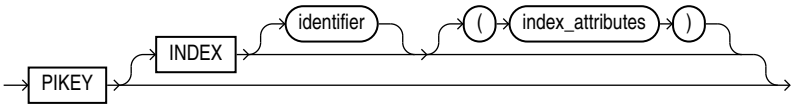
- "Usage of PATHS Clause" on page 6-46
- "Usage of create_index_paths_clause and alter_index_paths_clause" on page 6-47

namespace_mapping_clause ::=



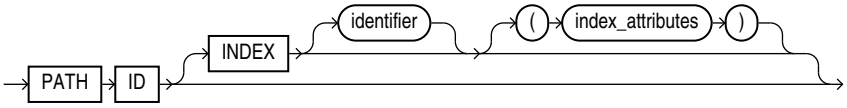
path_table_clause ::=

pikey_clause ::=



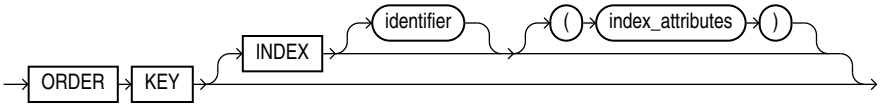
See Also: "Usage of pikey_clause, path_id_clause, and order_key_clause" on page 6-47

path_id_clause ::=



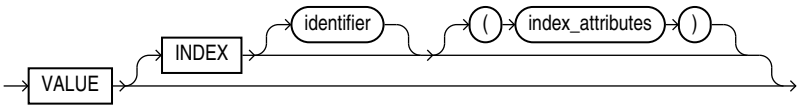
See Also: "Usage of pikey_clause, path_id_clause, and order_key_clause" on page 6-47

order_key_clause ::=



See Also: "Usage of pikey_clause, path_id_clause, and order_key_clause" on page 6-47

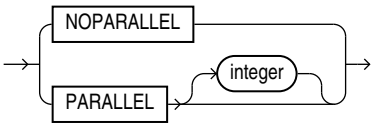
value_clause ::=



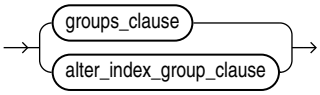
See Also: "Usage of value_clause" on page 6-47

drop_path_table_clause ::=

parallel_clause ::=

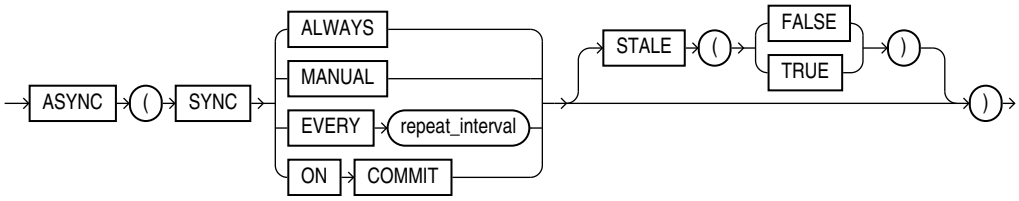


structured_clause ::=



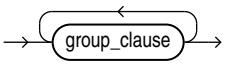
See Also: "Usage of groups_clause and alter_index_group_clause" on page 6-48

async_clause ::=



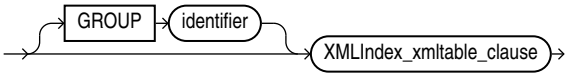
See Also: "Usage of async_clause" on page 6-47

groups_clause ::=



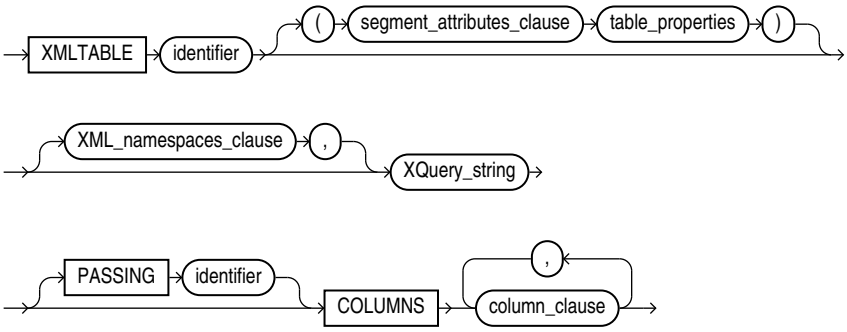
See Also: "Usage of groups_clause and alter_index_group_clause" on page 6-48

group_clause ::=



See Also: "Usage of groups_clause and alter_index_group_clause" on page 6-48

XMLIndex_xmltable_clause ::=

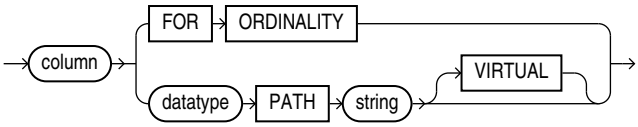


Syntax elements XML_namespaces_clause and XQuery_string are the same as for SQL/XML function `XMLTable`.

See Also:

- "Usage of XMLIndex_xmltable_clause" on page 6-48
- "XMLTABLE SQL/XML Function in Oracle XML DB" on page 4-11

column_clause ::=

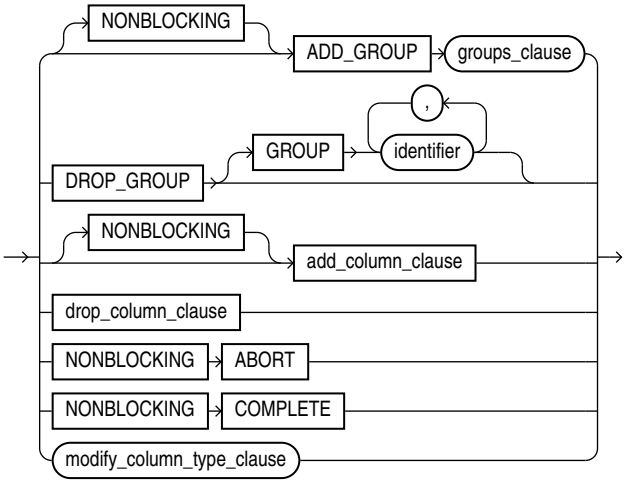


Syntax element column_clause is similar, but not identical, to XML_table_column in SQL/XML function `XMLTable`.

See Also:

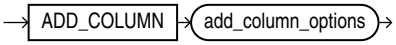
- "Usage of column_clause" on page 6-48
- "XMLTABLE SQL/XML Function in Oracle XML DB" on page 4-11

alter_index_group_clause ::=

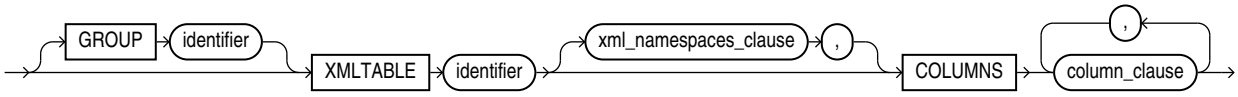


See Also: "Usage of groups_clause and alter_index_group_clause" on page 6-48

add_column_clause :==

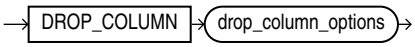


add_column_options :==

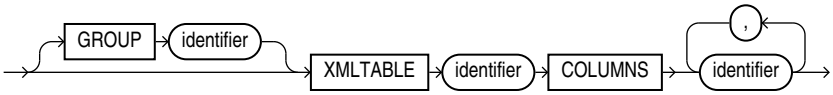


Syntax element XML_namespaces_clause is the same as for SQL/XML function `XMLTable`. See "XMLTABLE SQL/XML Function in Oracle XML DB" on page 4-11.

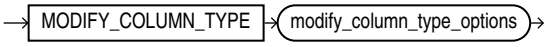
drop_column_clause :==



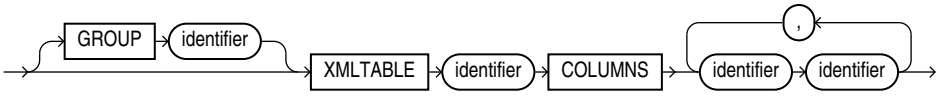
drop_column_options :==



modify_column_type_clause :==



modify_column_type_options :==



Usage of XMLIndex_parameters_clause

When you create an `XMLIndex` index, if there is no *`XMLIndex_parameters_clause`*, then the new index has only an unstructured component. If there is an *`XMLIndex_parameters_clause`*, but the `PARAMETERS` argument is empty (`''`), then the result is the same: an index with only an unstructured component.

See Also:

- *Oracle Database SQL Language Reference* for information about the use context for *`XMLIndex_parameters_clause`* in `CREATE INDEX`
- *Oracle Database SQL Language Reference* for information about the use context for *`XMLIndex_parameters_clause`* in `ALTER INDEX`

Usage of XMLIndex_parameters

The following considerations apply to using *`XMLIndex_parameters`*.

- There can be at most one *`XMLIndex_parameter_clause`* of each type in *`XMLIndex_parameters`*. For example, there can be at most one `PATHS` clause, at most one *`path_table_clause`*, and so on.
- If there is no *`structured_clause`* when you create an `XMLIndex` index, then the new index has only an unstructured component. If there is only a *`structured_clause`*, then the new index has only a structured component.

Usage of PATHS Clause

The following considerations apply to using the `PATHS` clause.

- There can be at most one `PATHS` clause in a `CREATE INDEX` statement. That is, there can be at most one occurrence of `PATHS` followed by *`create_index_paths_clause`*.
- Clause *`create_index_paths_clause`* is used only with `CREATE INDEX`; *`alter_index_paths_clause`* is used only with `ALTER INDEX`.

Usage of create_index_paths_clause and alter_index_paths_clause

The following considerations apply to using *create_index_paths_clause* and *alter_index_paths_clause*.

- The INDEX_ALL_PATHS keyword rebuilds the index to include all paths. This keyword is available only for *alter_index_paths_clause*, not *create_index_paths_clause*.
- An explicit list of paths to index can include wildcards and //.
- *XPaths_list* is a list of one or more XPath expressions, each of which includes only child axis, descendant axis, name test, and wildcard (*) constructs.
- If *XPaths_list* is omitted from *create_index_paths_clause*, all paths are indexed.
- For each unique namespace prefix that is used in an XPath expression in *XPaths_list*, a standard XML *namespace* declaration is needed, to provide the corresponding namespace information.
- You can change an index in ways that are not reflected directly in the syntax by dropping it and then creating it again as needed. For example, to change an index that was defined by including paths to one that is defined by excluding paths, drop it and then create it using EXCLUDE.

Usage of pikey_clause, path_id_clause, and order_key_clause

Syntactically, each of the clauses pikey_clause, path_id_clause, and order_key_clause is optional. A pikey index is created even if you do not specify a pikey_clause. To create a path id index or an order-key index, you must specify a path_id_clause or an order_key_clause, respectively.

Usage of value_clause

The following considerations apply to using *value_clause*.

- Column VALUE is created as VARCHAR2(4000).
- If clause *value_clause* consists only of the keyword VALUE, then the value index is created with the usual default attributes.
- If clause *path_id_clause* consists only of the keywords PATH ID, then the path-id index is created with the usual default attributes.
- If clause *order_key_clause* consists only of the keywords ORDER KEY, then the order-key index is created with the usual default attributes.

Usage of async_clause

The following considerations apply to using the ASYNC clause.

- Use this feature only with an XMLIndex index that has *only* an *unstructured* component. If you specify an ASYNC clause for an XMLIndex index that has a *structured* component, then an error is raised.
- ALWAYS means automatic synchronization occurs for each DML statement.
- MANUAL means no automatic synchronization occurs. You must manually synchronize the index using DBMS_XMLINDEX.syncIndex.
- EVERY *repeat_interval* means automatically synchronize the index at interval *repeat_interval*. The syntax of *repeat_interval* is the same as that for PL/SQL

package DBMS_SCHEDULER, and it must be enclosed in double quotation marks ("). To use EVERY you must have the CREATE JOB privilege.

- ON COMMIT means synchronize the index immediately after a commit operation. The commit does not return until the synchronization is complete. Since the synchronization is performed as a separate transaction, there can be a short period when the data is committed but index changes are not yet committed.
- STALE is optional. A value of TRUE means that query results might be stale; a value of FALSE means that query results are always up-to-date. The default value, and the only permitted explicitly specified value, is as follows.
  - For ALWAYS, STALE is TRUE.
  - For any other ASYNC option besides ALWAYS, STALE is FALSE.

Usage of groups_clause and alter_index_group_clause

Clause *groups_clause* is used only with CREATE INDEX (or following ADD GROUP in clause *alter_index_group_clause*). Clause *alter_index_group_clause* is used only with ALTER INDEX.

Usage of XMLIndex_xmltable_clause

The following considerations apply to using *XMLIndex_xmltable_clause*.

- The *XQuery_string* expression in *XMLIndex_xmltable_clause* must not use the XQuery functions ora:view (deprecated), fn:doc, or fn:collection.
- Oracle XML DB raises an error if a given *XMLIndex_xmltable_clause* contains more than one *column_clause* of data type XMLType. To achieve the effect of defining two such virtual columns, you must instead add a separate *group_clause*.
- The PASSING clause in *XMLIndex_xmltable_clause* is optional. If not present, then an XMLType column is passed implicitly, as follows:
  - For the first *XMLIndex_xmltable_clause* in a parameters clause, the XMLType column being indexed is passed implicitly. (When indexing an XMLType table, pseudocolumn OBJECT_VALUE is passed.)
  - For each subsequent *XMLIndex_xmltable_clause*, the VIRTUAL XMLType column of the preceding *XMLIndex_xmltable_clause* is passed implicitly.

Usage of column_clause

When you use multilevel chaining of XMLTable in an XMLIndex index, the XMLTable table at one level corresponds to an XMLType column at the previous level. The syntax description shows keyword VIRTUAL as optional. In fact, it is used only for such an XMLType column, in which case it is *required*. It is an error to use it for a non-XMLType column. VIRTUAL specifies that the XMLType column itself is not materialized, meaning that its data is stored in the index only in the form of the relational columns specified by its corresponding XMLTable table.

Indexing XML Data for Full-Text Queries

When you need full-text search over XML data, Oracle recommends that you store your XMLType data as binary XML and you use XQuery Full Text (XQFT). You use an XML search index for this. This is the topic of this section.

If portability and standardized code is not a concern, or if your XMLType data is stored object-relationally, then you can alternatively use the Oracle-specific full-text constructs and syntax provided by Oracle Text, specifically Oracle SQL function contains or Oracle XPath function ora:contains. This is covered in Appendix E.

See Also:

- Example 6–43, "Full-Text Query with XQuery Pragma ora:use_xmltext_idx" on page 6-52
- Appendix E, "Full-Text Search over XML Data Without XQuery" for more information about using Oracle Text operations with Oracle XML DB

You can perform XQuery Full Text (XQFT) queries on XMLType data that is stored as binary XML. If you use an XQFT full-text predicate in an XMLExists expression within a SQL WHERE clause, then you must create an **XML search index**. This section describes the creation and use of such an index.

See Also: "Support for XQuery Full Text" on page 4-27

Creating and Using an XML Search Index

To create an XML search index you must be granted database role CTXAPP. More generally, this role is needed to create Oracle Text indexes, to set Oracle Text index preferences, or to use Oracle Text PL/SQL packages.

Before creating the index, you must create an Oracle Text path section group and set its XML_ENABLE attribute to t. This makes the path section group XML-aware.

For best performance, create an index preference of type BASIC_STORAGE in the Oracle Text data dictionary, specifying the following attributes:

- D_TABLE_CLAUSE – Specify SECUREFILE storage for column DOC of index data table $D, which contains information about the structure of your XML documents. Specify *caching* and medium *compression*.
- I_TABLE_CLAUSE – Specify SECUREFILE storage for column TOKEN_INFO of index data table $I, which contains information about full-text tokens and their occurrences in the indexed documents. Specify *caching* (but not compression).

This is illustrated in Example 6–38, which uses a non XML-schema-based XMLType table, po_binxml (which has the same data as table purchaseorder in standard database schema OE).

Example 6–38 Creating an XML Search Index

```
BEGIN
  CTX_DDL.create_section_group('mysecgroup', 'PATH_SECTION_GROUP');
  CTX_DDL.set_sec_grp_attr('mysecgroup', 'XML_ENABLE', 'T');

  CTX_DDL.create_preference('mypref', 'BASIC_STORAGE');
  CTX_DDL.set_attribute('mypref',
                        'D_TABLE_CLAUSE',
                        'TABLESPACE my_ts
                         LOB(DOC) STORE AS SECUREFILE
                         (TABLESPACE my_ts COMPRESS MEDIUM CACHE)');
  CTX_DDL.set_attribute('mypref',
                        'I_TABLE_CLAUSE',
                        'TABLESPACE my_ts
                         LOB(TOKEN_INFO) STORE AS SECUREFILE
```

```
                        (TABLESPACE my_ts NOCOMPRESS CACHE)');
END;
/

CREATE INDEX po_ctx_idx ON po_binxml(OBJECT_VALUE)
  INDEXTYPE IS CTXSYS.CONTEXT
  PARAMETERS('storage mypref section group mysecgroup');
```

Index preference BASIC_STORAGE specifies the tablespace and creation parameters for the database tables and indexes that constitute an Oracle Text index.

See Also:

- *Oracle Text Reference* for information about section groups
- *Oracle Text Reference* for information about procedure CTX_DDL.set_sec_grp_attr
- *Oracle Text Reference* for information about procedure CTX_DDL.create_preference
- *Oracle Text Reference* for information about procedure CTX_DDL.set_attribute
- *Oracle Text Reference* for information about preference BASIC_STORAGE, D_TABLE_CLAUSE, and I_TABLE_CLAUSE

Example 6–39 queries the data to retrieve the Description elements whose text contains both Big and Street, in that order.

Example 6–39 XQuery Full Text Query

```
SELECT XMLQuery('for $i in /PurchaseOrder/LineItems/LineItem/Description
                  where $i[. contains text "Big" ftand "Street"]
                return <Title>{$i}</Title>'
                PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM po_binxml
  WHERE XMLExists('/PurchaseOrder/LineItems/LineItem/Description
                   [. contains text "Big" ftand "Street"]'
                  PASSING OBJECT_VALUE);
```

Example 6–40 shows the execution plan for the query, which indicates that index po_ctx_idx is picked up.

Example 6–40 Execution Plan for XQuery Full Text Query

```
-----------------------------------------------------------------------------------------
| Id  | Operation                    | Name       | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |            |     1 |  2014 |     4   (0)| 00:00:01 |
|   1 |  TABLE ACCESS BY INDEX ROWID| PO_BINXML  |     1 |  2014 |     4   (0)| 00:00:01 |
|*  2 |   DOMAIN INDEX               | PO_CTX_IDX |       |       |     4   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - access("CTXSYS"."CONTAINS"(SYS_MAKEXML(0,"XMLDATA"),'<query><textquery
              grammar="CONTEXT" lang="english"> ( ( {Big} ) and ( {Street} ) )  INPATH
              (/PurchaseOrder/LineItems/LineItem/Description)</textquery></query>')>0)

Note
-----
```

```
   - dynamic sampling used for this statement (level=2)
   - Unoptimized XML construct detected (enable XMLOptimizationCheck for more information)

21 rows selected.
```

What To Do If an XML Search Index Is Not Picked Up

If you use an XQuery full-text predicate in an `XMLExists` expression within a SQL `WHERE` clause, but you do not create an XML search index or the index cannot be used for some reason, then compile-time error ORA-18177 is raised.

If this error is raised then your execution plan does not indicate that the index is picked up: in the plan you do not see operation `DOMAIN INDEX` followed by the name of the index.

In that case, try to change your query to enable the index to be used. The following conditions must both apply for the index to be picked up:

- The expression that computes the XML nodes for the search context must be an XPath expression whose steps are only along *forward* and *descendent axes*.
- You can pass only one `XMLType` instance as a SQL expression in the `PASSING` clause of SQL/XML function `XMLExists`, and each of the other, non-`XMLType` SQL expressions in that clause must be either a *compile-time constant* of a SQL built-in data type or a *bind variable* that is bound to an instance of such a data type.

Pragma ora:no_schema: Using XML Schema-Based Data with XQuery Full Text

Oracle recommends in general that you use *non* XML Schema-based `XMLType` data when you use XQuery Full Text and an XML search index. You can, however, use XML Schema-based `XMLType` data stored as binary XML, provided you understand how it is used. This section covers this.

By default, when an XML search index is used to evaluate XML Schema-based data, compile-time error ORA-18177 is raised. This is because the full-text indexing itself makes no use of the associated XML schema: it is not type-aware. It treats all of the text that it applies to as untyped. This error is raised even if you type-cast data appropriately and thus do not depend on the XML schema to cast types implicitly. Example 6–41 illustrates this.

Example 6–41 XQuery Full Text Query with XML Schema-Based Data: Error ORA-18177

```
SELECT XMLQuery('/PurchaseOrder/LineItems/LineItem'
                PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM oe.purchaseorder
  WHERE XMLExists('/PurchaseOrder
                   [LineItems/LineItem/@ItemNumber > xs:integer("20")
                    and Actions/Action/User contains text "KPARTNER"]'
                  PASSING OBJECT_VALUE);
  FROM oe.purchaseorder
          *
ERROR at line 3:
ORA-18177: XQuery full text expression '/PurchaseOrder
[LineItems/LineItem/@ItemNumber > xs:integer("20")
and Actions/Action/User contains text "KPARTNER"]'
cannot be evaluated using XML text index
```

The error raised draws this to your attention, in case you might be expecting a full-text condition in your query to depend on XML Schema types and typed operations.

In order to use a condition that depends on types you must explicitly cast the relevant XQuery expressions to the appropriate types. Do not expect Oracle XML DB to use the XML schema to perform implicit type casting. Failure to type-cast appropriately can lead to results that you might not expect.

Example 6–42 shows a query of XML Schema-based data that uses explicit type-casting to ensure that the proper condition is evaluated.

Example 6–42 Using XQuery Pragma ora:no_schema with XML Schema-Based Data

```
SELECT XMLQuery('/PurchaseOrder/LineItems/LineItem'
                PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM oe.purchaseorder
  WHERE XMLExists('(# ora:no_schema #)
                   {/PurchaseOrder
                    [LineItems/LineItem/@ItemNumber > xs:integer("20")
                     and Actions/Action/User contains text "KPARTNER"]}'
                  PASSING OBJECT_VALUE);
```

However, most uses of XQuery Full Text expressions, even with XML Schema-based data, do not involve data that is typed. Just remember that if you do use a condition that makes use of typed data then you must cast to the proper type.

In sum, if you are sure that your query does not involve typed data, or if you judge that it is all right to treat particular typed data as if it were untyped, or if you explicitly type-cast any data that needs to be typed, then you can use Oracle XQuery pragma `ora:no_schema` in your query to inhibit raising the error and allow evaluation of the query using an XML search index.

Pragma ora:use_xmltext_idx: Forcing the Use of an XML Search Index

A given query involving XML data can be evaluated in various ways, depending on the existence of different indexes and other factors. Sometimes the default evaluation method is not the most performant and it would be more efficient to force the use of an existing XML search index. You can use XQuery pragma `ora:use_xmltext_idx` to do this. (An XML search index applies only to `XMLType` data stored as binary XML.)

For example, a `WHERE` clause might include two `XMLExists` expressions, only one of which involves an XQuery full-text condition, and you might have an `XMLIndex` index that applies to the `XMLExists` expression that has no full-text condition. With such a query it is typically more efficient to use an XML search index to evaluate the entire `WHERE` clause.

Even in some cases where there is no full-text condition in the query, the use of an XML search index can provide the most efficient query evaluation.

The query in Example 6–43 illustrates the use of pragma `ora:use_xmltext_idx`. Only the first of the `XMLExists` clauses uses a full-text condition. Because of the pragma, the full-text index (`po_ctx_idx`, created in Example 6–38) is used for both `XMLExists` clauses.

Example 6–43 Full-Text Query with XQuery Pragma ora:use_xmltext_idx

```
SELECT XMLQuery('/PurchaseOrder/LineItems/LineItem'
                PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM po_binxml
  WHERE XMLExists('/PurchaseOrder/LineItems/LineItem
                   [Description contains text "Picnic"]' PASSING OBJECT_VALUE)
    AND XMLExists('(# ora:use_xmltext_idx #) {/PurchaseOrder[User="SBELL"]}'
                  PASSING OBJECT_VALUE);
```

Migrating from Using Oracle Text Index to XML Search Index

The XQuery and XPath Full Text (XQFT) standard is supported by Oracle XML DB starting with Oracle Database 12c Release 1 (12.1). This support applies only to `XMLType` data stored as binary XML. Prior to that release, for full-text querying of XML data you could use only an Oracle Text index that was not XML-enabled (not an XML search index), and your full-text queries necessarily used Oracle-specific constructs: SQL function `CONTAINS` or XPath function `ora:contains`.

If you have legacy code that does this, Oracle recommends that you migrate that code to use XQFT. This section provides information about which XQFT constructs you can use to replace the use of `CONTAINS` and `ora:contains` in queries.

In addition to its use for full-text queries, an Oracle Text index that is not XML-enabled (is not an XML search index) can also be used with the Oracle Text structure operator `HASPATH`, which tests for the existence of a given document section; that is, it tests whether a given XPath expression has a non-null target.

This use of the index can also be replaced by the use of an XML search index. To replace a query that uses `HASPATH` by one that uses a simple XQuery expression, you use Oracle XQuery pragma `ora:use_xmltext_idx` to specify that the XML search index is to be picked up. This section also illustrates this.

Table 6–9 provides a mapping from typical queries that use Oracle-specific constructs to queries that use XQuery Full Text.

Table 6–9 Migrating Oracle-Specific XML Queries to XQuery Full Text

Original Example	Replacement Example

`CONTAINS(t.x, '`**`HASPATH`** `(/P/LIs/LI/Description`[1]`)') > 0`	`XMLExists('`**`(# ora:use_xmltext_idx #)`**
	`{$d/P/LIs/LI/Description`[1]`}'`
	`PASSING t.x AS "d")`
	Or if the data is XML Schema-based:
	`XMLExists('`**`(# ora:use_xmltext_idx #)`**
	`{`**`(# ora:no_schema #)`**
	`{$d/P/LIs/LI/Description`[1]`}}'`
	`PASSING t.x AS "d")`

`CONTAINS(t.x, 'Big INPATH`
`(/P/LIs/LI/Description)') > 0`
	`XMLExists('$d/P/LIs/LI/Description`
	`[. contains text "Big"]'`
	`PASSING t.x AS "d")`
	Or if the data is XML Schema-based:
	`XMLExists('`**`(# ora:no_schema #)`**
	`{$d/P/LIs/LI/Description`
	`[. contains text "Big"]}'`
	`PASSING t.x AS "d")`

`XMLExists('$d/P/LIs/LI/Description`
`[`**`ora:contains`**`(., "Big `**`AND`**` Street") > 0]'`
`PASSING t.x AS "d")`
	`XMLExists('$d/P/LIs/LI/Description`
	`[. contains text "Big" `**`ftand`**` "Street"]'`
	`PASSING t.x AS "d")`

`CONTAINS(t.x, '(Big) `**`AND`**` (Street) INPATH`
`(/P/LIs/LI/Description)') > 0`
	`XMLExists('$d/P/LIs/LI/Description`
	`[. contains text "Big" `**`ftand`**` "Street"]'`
	`PASSING t.x AS "d")`

`CONTAINS(t.x, '(Big) `**`OR`**` (Street) INPATH`
`(/P/LIs/LI/Description)') > 0`
	`XMLExists('$d/P/LIs/LI/Description`
	`[. contains text "Big" `**`ftor`**` "Street"]'`
	`PASSING t.x AS "d")`

`CONTAINS(t.x, '({Big}) `**`NOT`**` ({Street}) INPATH`
`(/P/LIs/LI/Description)') > 0`
	`XMLExists('$d/P/LIs/LI/Description`
	`[. contains text`
	`"Big" `**`ftand ftnot`**` "Street"]'`
	`PASSING t.x AS "d")`

Table 6–9 (Cont.) Migrating Oracle-Specific XML Queries to XQuery Full Text

Original Example	Replacement Example
`CONTAINS(t.x, '({Street}) MNOT ({Big Street}) INPATH (/P/LIs/LI/Description)') > 0`	`XMLExists('$d/P/LIs/LI/Description [. contains text "Street" not in "Big Street"]' PASSING t.x AS "d")`
`CONTAINS(t.x, '(NEAR (({Big}, {Street}), 3) INPATH (/P/LIs/LI/Description)') > 0`	`XMLExists('$d/P/LIs/LI/Description [. contains text "Big" ftand "Street" window 3 words]' PASSING t.x AS "d")`
(Not applicable – Oracle Text queries are not XML namespace aware.)	`XMLExists('declare namespace ipo="http://www.example.com/IPO"; /ipo:P/ipo:LIs/ipo:LI/ipo:Description [. contains text "Big"]' PASSING t.x AS "d")`

[1] The path test can contain a predicate expression, which is the same for both the original query (with `HASPATH`) and its replacement. For example: `/PurchaseOrder/LineItems/LineItem/Part[@Id < "31415927"]`.

Indexing XMLType Data Stored Object-Relationally

You can effectively index `XMLType` data that is stored object-relationally by creating B-tree indexes on the underlying database columns that correspond to XML nodes.

If the data to be indexed is a *singleton*, that is, if it can occur only once in any XML instance document, then you can use a *shortcut* of ostensibly creating a function-based index, where the expression defining the index is a functional application, with an XPath-expression argument that targets the singleton data. A shortcut is defined for `XMLCast` applied to `XMLQuery`, and another shortcut is defined for (deprecated) Oracle SQL function `extractValue`.

In many cases, Oracle XML DB then automatically creates appropriate indexes on the underlying object-relational tables or columns; it does *not* create a function-based index on the targeted `XMLType` data as the `CREATE INDEX` statement would suggest.

In the case of the `extractValue` shortcut, the index created is a B-tree index. In the case of `XMLCast` applied to `XMLQuery`, the index created is a function-based index on the scalar value resulting from the functional expression. "Indexing Non-Repeating Text Nodes or Attribute Values" on page 6-54 describes this.

If the data to be indexed is a *collection*, then you cannot use such a shortcut; you must create the B-tree indexes manually. "Indexing Repeating (Collection) Elements" on page 6-55 describes this.

> **See Also:** Appendix E, "Full-Text Search over XML Data Without XQuery" for information about indexing `XMLType` data stored object-relationally for full-text search

Indexing Non-Repeating Text Nodes or Attribute Values

Table `purchaseorder` in sample database schema `OE` is stored object-relationally. Each purchase-order document has a single `Reference` element; this element is a singleton. You can thus use a shortcut to create an index on the underlying object-relational data.

Example 6–44 shows a `CREATE INDEX` statement that ostensibly tries to create a function-based index using `XMLCast` applied to `XMLQuery`, targeting the text content of element `Reference`. (The content of this element is only text, so targeting the element is the same as targeting its text node using XPath node test `text()`.)

Example 6–45 ostensibly tries to create a function-based index using (deprecated) Oracle SQL function `extractValue`, targeting the same data.

Example 6–44 CREATE INDEX Using XMLCAST and XMLQUERY on a Singleton Element

```
CREATE INDEX po_reference_ix ON purchaseorder
  (XMLCast(XMLQuery ('$p/PurchaseOrder/Reference' PASSING po.OBJECT_VALUE AS "p"
                                                  RETURNING CONTENT)
              AS VARCHAR2(128)));
```

Example 6–45 CREATE INDEX Using EXTRACTVALUE on a Singleton Element

```
CREATE INDEX po_reference_ix ON purchaseorder
  (extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference'));
```

In reality, in both Example 6–44 and Example 6–45 no function-based index is created on the targeted `XMLType` data. Instead, Oracle XML DB rewrites the `CREATE INDEX` statements to create indexes on the underlying scalar data.

> **See Also:** Example 19–7 and Example 19–8 on page 19-7 for information about XPath rewrite as it applies to such `CREATE INDEX` statements

In some cases when you use either of these shortcuts, the `CREATE INDEX` statement is not able to create an index on the underlying scalar data as described, and it instead actually does create a function-based index on the referenced `XMLType` data. (This is so, even if the *value* of the index might be a scalar.)

If this happens, drop the index, and create instead an `XMLIndex` index with a structured component that targets the same XPath. As a general rule, Oracle recommends against using a function-based index on `XMLType` data.

This is an instance of a general rule for `XMLType` data, regardless of the storage method used: Use an `XMLIndex` with a structured component instead of a function-based index. This rule applies starting with Oracle Database 11*g* Release 2 (11.2). Respecting this rule obviates the overhead associated with maintenance operations on function-based indexes, and it can increase the number of situations in which the optimizer can correctly select the index.

> **See Also:** "Function-Based Indexes Are Deprecated for XMLType" on page 6-5

Indexing Repeating (Collection) Elements

In object-relational storage of `XMLType`, a collection is stored as an ordered collection table (OCT) of an `XMLType` instance, which means that you can directly access its members. Because the object-relational storage model directly reflects the fine-grained structure of the XML data, you can create indexes that target individual collection members.

You must create such indexes manually. The special feature of automatically creating B-tree indexes when you ostensibly create a function-based index for (deprecated) Oracle SQL function `extractValue` does *not* apply to collections (the XPath expression passed to `extractValue` must target a singleton).

To create B-tree indexes for a collection, you must understand the structure of the SQL object that is used to manage the collection. Given this information, you can use conventional object-relational SQL code to created the indexes directly on the appropriate SQL-object attributes. Refer to "Guideline: Create indexes on ordered

collection tables" on page 19-8 for an example of how to do this.

7

Transformation and Validation of XMLType Data

This chapter describes the SQL functions and `XMLType` APIs for transforming `XMLType` data using XSLT stylesheets. It also explains the various functions and APIs available for validating the `XMLType` instance against an XML schema.

This chapter contains these topics:

- XSL Transformation and Oracle XML DB
- Validation of XMLType Instances

XSL Transformation and Oracle XML DB

The W3C XSLT Recommendation defines an XML language for specifying how to transform XML documents from one form to another. See `http://www.w3.org/TR/xslt` for information about the XSLT standard.

Transformation can include mapping from one XML schema to another or mapping from XML to some other format such as HTML or WML.

XSL transformation can be costly in terms of the amount of memory and processing required. In typical XSL processors, the entire source document and stylesheet must be parsed and loaded into memory, before processing can begin. Typically, XSL processors use DOM to provide dynamic memory representations of document and stylesheet, to allow random access to their different parts. The XSL processor then applies the stylesheet to the source document, generating a third document.

Parsing and loading the document and stylesheet into memory before beginning transformation requires significant memory and processor resources. It is especially inefficient when only a small part of the document needs to be transformed.

Oracle XML DB includes an XSLT processor that performs XSL transformations *inside the database*. In this way, it can provide XML-specific optimizations that can significantly reduce the memory required to perform the transformation, eliminate overhead associated with parsing, and reduce network traffic.

These optimizations are available, however, *only* when the source for the transformation is a *schema-based* XML document. In that case, there is no need to parse before processing can begin. The Oracle XML DB lazily loaded virtual DOM loads content only on demand, as the nodes are accessed. This also reduces the memory required, because only parts of the document that need to be processed are loaded.

You can transform XML data in the following ways:

- In Oracle Database – Using Oracle SQL function `XMLtransform`, `XMLType` method `transform()`, or PL/SQL package `DBMS_XSLPROCESSOR`
- In the middle tier – Using Oracle XML Developer's Kit transformation options , such as XSLT Processor for Java.

Each of these XML transformation methods takes as input a source XML document and an XSL stylesheet in the form of `XMLType` instances. For SQL function `XMLtransform` and `XMLType` method `transform()`, the result of the transformation can be an XML document or a non-XML document, such as HTML. However, for PL/SQL package `DBMS_XSLPROCESSOR`, the result of the transformation is expected to be a valid XML document. Any HTML data generated by a transformation using package `DBMS_XSLPROCESSOR` is XHTML data, which is both valid XML data and valid HTML data.

Example 7–1 shows part of an XSLT stylesheet, `PurchaseOrder.xsl`. The complete stylesheet is given in "XSLT Stylesheet Example, PurchaseOrder.xsl" on page A-41.

Example 7–1 XSLT Stylesheet Example: PurchaseOrder.xsl

```
<?xml version="1.0" encoding="WINDOWS-1252"?>
<xsl:stylesheet version="1.0"
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  xmlns:xdb="http://xmlns.oracle.com/xdb"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <xsl:template match="/">
    <html>
      <head/>
      <body bgcolor="#003333" text="#FFFFCC" link="#FFCC00" vlink="#66CC99" alink="#669999">
        <FONT FACE="Arial, Helvetica, sans-serif">
          <xsl:for-each select="PurchaseOrder"/>
          <xsl:for-each select="PurchaseOrder">
            <center>
              <span style="font-family:Arial; font-weight:bold">
                <FONT COLOR="#FF0000">
                  <B>PurchaseOrder </B>
                </FONT>
              </span>
            </center>
            <br/>
            <center>
              <xsl:for-each select="Reference">
                <span style="font-family:Arial; font-weight:bold">
                  <xsl:apply-templates/>
                </span>
              </xsl:for-each>
            </center>
          </xsl:for-each>
          <P>
            <xsl:for-each select="PurchaseOrder">
              <br/>
            </xsl:for-each>
            <P/>
            <P>
              <xsl:for-each select="PurchaseOrder">
                <br/>
              </xsl:for-each>
            </P>
          </P>
          <xsl:for-each select="PurchaseOrder"/>
          <xsl:for-each select="PurchaseOrder">
            <table border="0" width="100%" BGCOLOR="#000000">
              <tbody>
                <tr>
                  <td WIDTH="296">
                    <P>
```

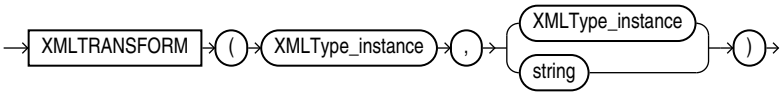
```
    <B>
      <FONT SIZE="+1" COLOR="#FF0000" FACE="Arial, Helvetica, sans-serif">Internal</FONT>
    </B>
  </P>

  ...

</td>
<td width="93"/>
<td valign="top" WIDTH="340">
  <B>
    <FONT COLOR="#FF0000">
      <FONT SIZE="+1">Ship To</FONT>
    </FONT>
  </B>
  <xsl:for-each select="ShippingInstructions">
    <xsl:if test="position()=1"/>
  </xsl:for-each>
  <xsl:for-each select="ShippingInstructions">
  </xsl:for-each>

    ...
```

These is nothing Oracle XML DB-specific about the stylesheet of Example 7–1. A stylesheet can be stored in an `XMLType` table or column or stored as non-schema-based XML data inside Oracle XML DB Repository.

SQL Function XMLTRANSFORM and XMLType Method TRANSFORM()

Figure 7–1 shows the syntax of Oracle SQL function `XMLtransform`. This function takes as arguments an `XMLType` instance and an XSLT stylesheet. The stylesheet can be an `XMLType` instance or a `VARCHAR2` string literal. It applies the stylesheet to the instance and returns an `XMLType` instance.

Figure 7–1 XMLTRANSFORM Syntax



You can alternatively use `XMLType` method `transform()` as an alternative to Oracle SQL function `XMLtransform`. It has the same functionality.

Figure 7–2 shows how `XMLtransform` transforms an XML document by using an XSLT stylesheet. It returns the processed output as XML, HTML, and so on, as specified by the XSLT stylesheet. You typically use `XMLtransform` when retrieving or generating XML documents stored as `XMLType` in the database.

> **See Also:** Figure 1–3, "XMLType Storage" in Chapter 1, "Introduction to Oracle XML DB"

Figure 7–2 Using XMLTRANSFORM

XMLTRANSFORM and XMLType.transform(): Examples

The examples in this section illustrate how to use Oracle SQL function `XMLtransform` and `XMLType` method `transform()` to transform XML data stored as `XMLType` to various formats.

Example 7–2 sets up an XML schema and tables that are needed to run other examples in this chapter. The call to `deleteSchema` here ensures that there is no existing XML schema before creating one. If no such schema exists, then `deleteSchema` raises an error.

Example 7–2 Registering an XML Schema and Inserting XML Data

```
BEGIN
  -- Delete the schema, if it already exists.
  DBMS_XMLSCHEMA.deleteSchema('http://www.example.com/schemas/ipo.xsd',4);
END;
/
BEGIN
  -- Register the schema
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.example.com/schemas/ipo.xsd',
    SCHEMADOC => '<schema targetNamespace="http://www.example.com/IPO"
                          xmlns="http://www.w3.org/2001/XMLSchema"
                          xmlns:ipo="http://www.example.com/IPO">
                    <!-- annotation>
                      <documentation xml:lang="en">
                       International Purchase order schema for Example.com
                       Copyright 2000 Example.com. All rights reserved.
                      </documentation>
                    </annotation -->
                    <element name="purchaseOrder" type="ipo:PurchaseOrderType"/>
                    <element name="comment" type="string"/>
                    <complexType name="PurchaseOrderType">
                      <sequence>
                        <element name="shipTo"     type="ipo:Address"/>
                        <element name="billTo"     type="ipo:Address"/>
                        <element ref="ipo:comment" minOccurs="0"/>
                        <element name="items"      type="ipo:Items"/>
                      </sequence>
                      <attribute name="orderDate" type="date"/>
                    </complexType>
                    <complexType name="Items">
                      <sequence>
                        <element name="item" minOccurs="0" maxOccurs="unbounded">
                          <complexType>
                            <sequence>
                              <element name="productName" type="string"/>
                              <element name="quantity">
                                <simpleType>
                                  <restriction base="positiveInteger">
                                    <maxExclusive value="100"/>
                                  </restriction>
                                </simpleType>
                              </element>
                              <element name="USPrice"    type="decimal"/>
                              <element ref="ipo:comment" minOccurs="0"/>
                              <element name="shipDate"   type="date" minOccurs="0"/>
                            </sequence>
                            <attribute name="partNum" type="ipo:SKU" use="required"/>
                          </complexType>
```

```
                    </element>
                  </sequence>
                </complexType>
                <complexType name="Address">
                  <sequence>
                    <element name="name"    type="string"/>
                    <element name="street"  type="string"/>
                    <element name="city"    type="string"/>
                    <element name="state"   type="string"/>
                    <element name="country" type="string"/>
                    <element name="zip"     type="string"/>
                  </sequence>
                </complexType>
                <simpleType name="SKU">
                  <restriction base="string">
                    <pattern value="[0-9]{3}-[A-Z]{2}"/>
                  </restriction>
                </simpleType>
              </schema>',
    LOCAL     => TRUE,
    GENTYPES  => TRUE);
END;
/

-- Create table to hold XML purchase-order documents, and insert the documents
DROP TABLE po_tab;
CREATE TABLE po_tab (id NUMBER, xmlcol XMLType)
 XMLType COLUMN xmlcol
 XMLSCHEMA "http://www.example.com/schemas/ipo.xsd"
 ELEMENT "purchaseOrder";

INSERT INTO po_tab
  VALUES(1, XMLType(
              '<?xml version="1.0"?>
               <ipo:purchaseOrder
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xmlns:ipo="http://www.example.com/IPO"
                 xsi:schemaLocation="http://www.example.com/IPO
                                     http://www.example.com/schemas/ipo.xsd"
                 orderDate="1999-12-01">
                 <shipTo>
                   <name>Helen Zoe</name>
                   <street>121 Broadway</street>
                   <city>Cardiff</city>
                   <state>Wales</state>
                   <country>UK</country>
                   <zip>CF2 1QJ</zip>
                 </shipTo>
                 <billTo>
                   <name>Robert Smith</name>
                   <street>8 Oak Avenue</street>
                   <city>Old Town</city>
                   <state>CA</state>
                   <country>US</country>
                   <zip>95819</zip>
                 </billTo>
                 <items>
                   <item partNum="833-AA">
                     <productName>Lapis necklace</productName>
                     <quantity>1</quantity>
```

```
    <USPrice>99.95</USPrice>
    <ipo:comment>Want this for the holidays!</ipo:comment>
    <shipDate>1999-12-05</shipDate>
  </item>
 </items>
</ipo:purchaseOrder>'));
```

Example 7–3 stores an XSLT stylesheet, then retrieves it and uses it with Oracle SQL function `XMLTransform` to transform the XML data stored in Example 7–2.

Example 7–3 Using SQL Function XMLTRANSFORM to Apply an XSL Stylesheet

```
DROP TABLE stylesheet_tab;
CREATE TABLE stylesheet_tab (id NUMBER, stylesheet XMLType);
INSERT INTO stylesheet_tab
  VALUES (1,
          XMLType(
            '<?xml version="1.0" ?>
             <xsl:stylesheet version="1.0"
                             xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
               <xsl:template match="*">
                 <td>
                   <xsl:choose>
                     <xsl:when test="count(child::*) > 1">
                       <xsl:call-template name="nested"/>
                     </xsl:when>
                     <xsl:otherwise>
                       <xsl:value-of select="name(.)"/>:<xsl:value-of
                                                          select="text()"/>
                     </xsl:otherwise>
                   </xsl:choose>
                 </td>
               </xsl:template>
               <xsl:template match="*" name="nested" priority="-1" mode="nested2">
                 <b>
                   <!-- xsl:value-of select="count(child::*)"/ -->
                   <xsl:choose>
                     <xsl:when test="count(child::*) > 1">
                       <xsl:value-of select="name(.)"/>:<xsl:apply-templates
                                                          mode="nested2"/>
                     </xsl:when>
                     <xsl:otherwise>
                       <xsl:value-of select="name(.)"/>:<xsl:value-of
                                                          select="text()"/>
                     </xsl:otherwise>
                   </xsl:choose>
                 </b>
               </xsl:template>
             </xsl:stylesheet>'));

SELECT XMLSerialize(DOCUMENT XMLtransform(x.xmlcol, y.stylesheet)
                    AS VARCHAR2(1000))
  AS result FROM po_tab x, stylesheet_tab y WHERE y.id = 1;
```

This produces the following output (pretty-printed here for readability):

```
RESULT
------------------------------------------------------------
<td>
  <b>ipo:purchaseOrder:
    <b>shipTo:
```

```
      <b>name:Helen Zoe</b>
      <b>street:100 Broadway</b>
      <b>city:Cardiff</b>
      <b>state:Wales</b>
      <b>country:UK</b>
      <b>zip:CF2 1QJ</b>
    </b>
    <b>billTo:
      <b>name:Robert Smith</b>
      <b>street:8 Oak Avenue</b>
      <b>city:Old Town</b>
      <b>state:CA</b>
      <b>country:US</b>
      <b>zip:95819</b>
    </b>
    <b>items:</b>
  </b>
</td>
```

Example 7–4 uses `XMLType` method `transform()` with an XSL stylesheet created on the fly.

Example 7–4 Using XMLType Method TRANSFORM() with a Transient XSL Stylesheet

```
SELECT XMLSerialize(
         DOCUMENT
         x.xmlcol.transform(
           XMLType('<?xml version="1.0" ?>
                  <xsl:stylesheet
                      version="1.0"
                      xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
                    <xsl:template match="*">
                      <td>
                        <xsl:choose>
                          <xsl:when test="count(child::*) > 1">
                            <xsl:call-template name="nested"/>
                          </xsl:when>
                          <xsl:otherwise>
                            <xsl:value-of
                               select =
                                 "name(.)"/>:<xsl:value-of select="text()"/>
                          </xsl:otherwise>
                        </xsl:choose>
                      </td>
                    </xsl:template>
                    <xsl:template match="*" name="nested" priority="-1"
                                  mode="nested2">
                      <b>
                        <!-- xsl:value-of select="count(child::*)"/ -->
                        <xsl:choose>
                          <xsl:when test="count(child::*) > 1">
                            <xsl:value-of select="name(.)"/>:
                            <xsl:apply-templates mode="nested2"/>
                          </xsl:when>
                          <xsl:otherwise>
                            <xsl:value-of
                               select =
                                 "name(.)"/>:<xsl:value-of select="text()"/>
                          </xsl:otherwise>
                        </xsl:choose>
```

```
                    </b>
                  </xsl:template>
                </xsl:stylesheet>'))
        AS varchar2(1000))
  FROM po_tab x;
```

Example 7–5 uses `XMLTransform` to apply an XSL stylesheet to produce HTML code. PL/SQL constructor `XDBURIType` reads the XSL stylesheet from Oracle XML DB Repository.

Only part of the HTML result is shown in. Omitted parts are indicated with an ellipsis (. . .). Figure 7–3 shows what the transformed result looks like in a Web browser.

Example 7–5 Using XMLTRANSFORM to Apply an XSL Stylesheet Retrieved Using XDBURIType

```
SELECT
  XMLTransform(
    OBJECT_VALUE,
    XDBURIType('/source/schemas/poSource/xsl/purchaseOrder.xsl').getXML())
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

XMLTRANSFORM(OBJECT_VALUE, XDBURITYPE('/SOURCE/SCHEMAS/POSOURCE/XSL/PURCHASEORDER.XSL').GET
--------------------------------------------------------------------------------------------
<html xmlns:xdb="http://xmlns.oracle.com/xdb"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <head/>
  <body bgcolor="#003333" text="#FFFFCC" link="#FFCC00" vlink="#66CC99" alink="#669999">
    <FONT FACE="Arial, Helvetica, sans-serif">
      <center>
        <span style="font-family:Arial; font-weight:bold">
          <FONT COLOR="#FF0000">
            <B>PurchaseOrder </B>
          </FONT>
        </span>
      </center>
      <br/>
      <center>
        <span style="font-family:Arial; font-weight:bold">SBELL-2002100912333601PDT</span>
      </center>
      <P>
        <br/>
        <P/>
        <P>
          <br/>
        </P>
      </P>
      <table border="0" width="100%" BGCOLOR="#000000">
        <tbody>
          <tr>
            <td WIDTH="296">
              <P>
                <B>
                  <FONT SIZE="+1" COLOR="#FF0000" FACE="Arial, Helvetica,
                        sans-serif">Internal</FONT>
                </B>
              </P>
              <table border="0" width="98%" BGCOLOR="#000099">
                                                          . . .
              </table>
            </td>
            <td width="93">
            </td>
```

```
            <td valign="top" WIDTH="340">
              <B>
                <FONT COLOR="#FF0000">
                  <FONT SIZE="+1">Ship To</FONT>
                </FONT>
              </B>
              <table border="0" BGCOLOR="#999900">
                . . .
              </table>
            </td>
          </tr>
        </tbody>
      </table>
      <br/>
      <B>
        <FONT COLOR="#FF0000" SIZE="+1">Items:</FONT>
      </B>
      <br/>
      <br/>
      <table border="0">
        . . .
      </table>
    </FONT>
  </body>
</html>

1 row selected.
```

XSL Transformation Using DBUri Servlet

Figure 7–3 shows the result of applying an XSL transformation to XML content generated by the DBUri servlet. The URL is the following (it is split and truncated here):

```
http://localhost:8080/oradb/SCOTT/PURCHASEORDER/ROW/PurchaseOrder[Reference="SBELL-2003030912333601PDT"]
contenttype=text/html&transform=/home/SCOTT/xsl/purchaseOrder.xsl...
```

The presence of parameter `transform` causes the DBUri servlet to use SQL function `XMLTransform` to apply the XSL stylesheet at `/home/SCOTT/xsl/purchaseOrder.xsl` to the `PurchaseOrder` document that is identified by the main URL. The result of the transformation, which is HTML code, is returned to the browser for display. The URL also uses parameter `contentType` to specify that the MIME-type of the final document is `text/html`.

Figure 7–3 Database XSL Transformation of a PurchaseOrder Using DBUri Servlet

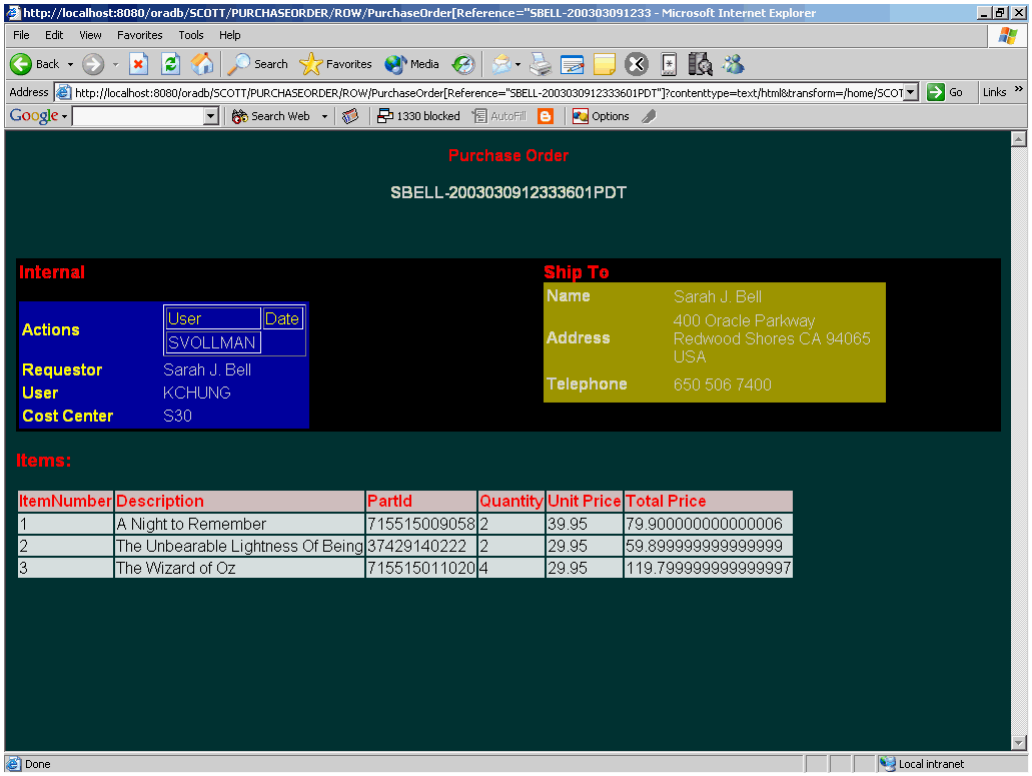
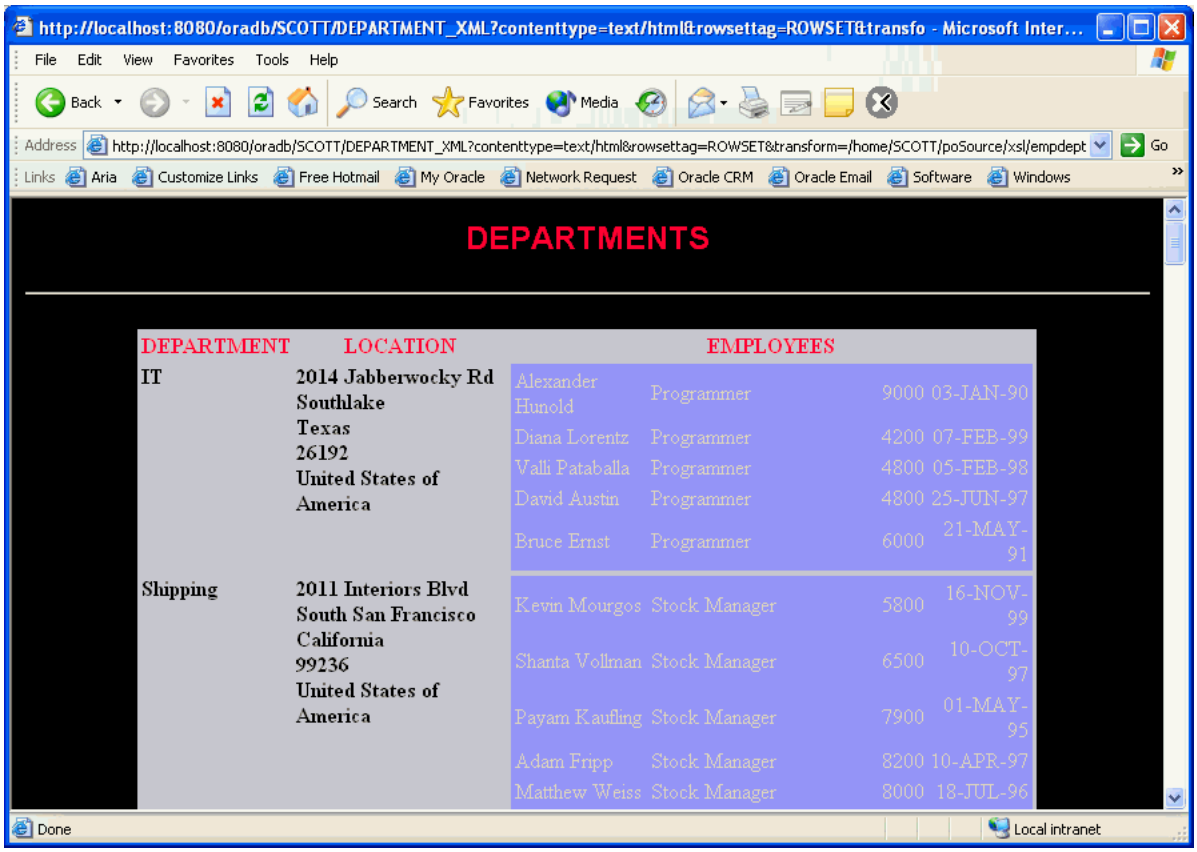


Figure 7–4 shows table `departments` displayed as an HTML document. You need no code to achieve this. You need only an `XMLType` view based on SQL/XML functions, an industry-standard XSL stylesheet, and `DBUri` servlet.

Figure 7–4 Database XSL Transformation of Departments Table Using DBUri Servlet



Validation of XMLType Instances

Often, besides knowing whether a particular XML document is well-formed, you need to know whether it conforms to a given XML schema, that is, whether it is valid with respect to that XML schema.

XML schema-based data that is stored as binary XML it is automatically validated fully whenever it is inserted or updated. This validation does not require building a DOM. It is done using streaming, which is efficient and minimizes memory use.

For `XMLType` data that is stored object-relationally, full validation requires building a DOM, which can be costly in terms of memory management. For this reason, Oracle XML DB does not automatically perform full validation when you insert or update data that is stored object-relationally.

However, in the process of decomposing XML data to store it object-relationally, Oracle XML DB does automatically perform partial validation, to ensure that the structure of the XML document conforms to the SQL data type definitions that were derived from the XML schema.

If you require full validation for `XMLType` data stored object-relationally, then consider validating on the client before inserting the data into the database or updating it.

You can use the following to perform full validation and manipulate the recorded validation status of XML documents:

- Oracle SQL function **`XMLIsValid`** and `XMLType` method **`IsSchemaValid()`** – Run the validation process unconditionally. Do not record any validation status. Return:

  - `1` if the document is determined to be *valid*.
  - `0` if the document is determined to be *invalid* or the validity of the document *cannot be determined*.

- `XMLType` method **`SchemaValidate()`** – Runs the validation process if the validation status is `0`, which it is by default. Sets the validation status to `1` if the document is determined to be *valid*. (Otherwise, the status remains `0`.)
- `XMLType` method **`isSchemaValidated()`** returns the recorded validation status of an `XMLType` instance.
- `XMLType` method **`setSchemaValidated()`** sets (records) the validation status of an `XMLType` instance.

Note that the validation status indicates knowledge of validity, as follows:

- `1` means that the document is known to be *valid*.
- `0` means that validity of the document is *unknown*. The document might have been shown to be invalid during a validation check, but that invalidity is not recorded. A recorded validation status of `0` indicates only a lack of knowledge about the document's validity.

See Also:

- "Partial and Full XML Schema Validation" on page 7-12
- *Oracle Database SQL Language Reference* for information about Oracle SQL function `XMLIsValid`
- *Oracle Database PL/SQL Packages and Types Reference* for information about `XMLType` methods `IsSchemaValid()`, `IsSchemaValidated()`, `SchemaValidate()`, and `setSchemaValidated()`

Partial and Full XML Schema Validation

This section describes the differences between partial and full XML schema validation used when inserting XML documents into the database.

Partial Validation

For binary XML storage, Oracle XML DB performs a full validation whenever an XML document is inserted into an XML schema-based `XMLType` table or column. For all other models of XML storage, Oracle XML DB performs only a partial validation of the document. This is because, except for binary XML storage, complete XML schema validation is quite costly, in terms of performance.

Partial validation ensures only that all of the mandatory elements and attributes are present, and that there are no unexpected elements or attributes in the document. That is, it ensures only that the structure of the XML document conforms to the SQL data type definitions that were derived from the XML schema. Partial validation does not ensure that the instance document is fully compliant with the XML schema.

Example 7–6 provides an example of failing partial validation while inserting an XML document into table `PurchaseOrder`, which is stored object-relationally.

Example 7–6 Error When Inserting Incorrect XML Document (Partial Validation)

```
INSERT INTO purchaseorder
  VALUES(XMLType(bfilename('XMLDIR', 'InvalidElement.xml'),
                 nls_charset_id('AL32UTF8')));
```

```
  VALUES(XMLType(bfilename('XMLDIR', 'InvalidElement.xml'),
         *
ERROR at line 2:
ORA-30937: No schema definition for 'UserName' (namespace '##local') in parent
'/PurchaseOrder'
```

Full Validation

Loading XML data into XML schema-based binary XML storage causes full validation against the target XML schemas. Otherwise, regardless of the `XMLType` storage model used, you can force full validation of XML instance documents against an XML schema at any time, using either of the following:

- Table level `CHECK` constraint
- PL/SQL `BEFORE INSERT` trigger

Both approaches ensure that only valid XML documents can be stored in the `XMLType` table.

The advantage of a `TABLE CHECK` constraint is that it is easy to code. The disadvantage is that it is based on Oracle SQL function `XMLisValid`, so it can only indicate whether or not the XML document is valid. If an XML document is invalid, a `TABLE CHECK` constraint cannot provide any information as to *why* it is invalid.

A `BEFORE INSERT` trigger requires slightly more code. The trigger validates the XML document by invoking `XMLType` method `schemaValidate()`. The advantage of using `schemaValidate()` is that the exception raised provides additional information about what was wrong with the instance document. Using a `BEFORE INSERT` trigger also makes it possible to attempt corrective action when an invalid document is encountered.

Full XML Schema Validation Costs Processing Time and Memory Usage Unless you are using binary XML storage, full XML schema validation costs processing time and memory. You should thus perform full XML schema validation only when necessary. If you can rely on your application to validate an XML document, you can obtain higher overall throughput with non-binary XML storage, by avoiding the overhead associated with full validation. If you cannot be sure about the validity of incoming XML documents, you can rely on the database to ensure that an `XMLType` table or column contains only schema-valid XML documents.

Example 7–7 shows how to force a full XML schema validation by adding a `CHECK` constraint to an `XMLType` table. In Example 7–7, the XML document `InvalidReference` is a not valid with respect to the XML schema. The XML schema defines a minimum length of 18 characters for the text node associated with the `Reference` element. In this document, the node contains the value `SBELL-20021009`, which is only 14 characters long. Partial validation would not catch this error. Unless the constraint or trigger is present, attempts to insert this document into the database would succeed.

Example 7–7 Forcing Full XML Schema Validation Using a CHECK Constraint

```
ALTER TABLE purchaseorder
  ADD CONSTRAINT validate_purchaseorder
  CHECK (XMLIsValid(OBJECT_VALUE) = 1);

Table altered.

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'InvalidReference.xml'),
                  nls_charset_id('AL32UTF8')));
```

```
INSERT INTO purchaseorder
*

ERROR at line 1:
ORA-02290: check constraint (QUINE.VALIDATE_PURCHASEORDER) violated
```

Pseudocolumn OBJECT_VALUE can be used to access the content of an XMLType table from within a trigger. Example 7–8 illustrates this, showing how to use a BEFORE INSERT trigger to validate that the data being inserted into the XMLType table conforms to the specified XML schema.

Example 7–8 Enforcing Full XML Schema Validation Using a BEFORE INSERT Trigger

```
CREATE OR REPLACE TRIGGER validate_purchaseorder
   BEFORE INSERT ON purchaseorder
   FOR EACH ROW
BEGIN
  IF (:new.OBJECT_VALUE IS NOT NULL) THEN :new.OBJECT_VALUE.schemavalidate();
  END IF;
END;
/

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'InvalidReference.xml'),
                  nls_charset_id('AL32UTF8')));
  VALUES (XMLType( bfilename('XMLDIR', 'InvalidReference.xml'),
          *
ERROR at line 2:
ORA-31154: invalid XML document
ORA-19202: Error occurred in XML processing
LSX-00221: "SBELL-20021009" is too short (minimum length is 18)
LSX-00213: only 0 occurrences of particle "sequence", minimum is 1
ORA-06512: at "SYS.XMLTYPE", line 354
ORA-06512: at "QUINE.VALIDATE_PURCHASEORDER", line 3
ORA-04088: error during execution of trigger 'QUINE.VALIDATE_PURCHASEORDER'
```

Validating XML Data Stored as XMLType: Examples

The examples in this section illustrate how to use Oracle SQL function XMLIsValid and XMLType methods isSchemaValid() and schemaValidate() to validate XML data being stored as XMLType in Oracle XML DB.

Example 7–9 and Example 7–10 show how to validate an XML instance against an XML schema using PL/SQL method isSchemaValid().

Example 7–9 Validating XML Using Method ISSCHEMAVALID() in SQL

```
SELECT x.xmlcol.isSchemaValid('http://www.example.com/schemas/ipo.xsd',
                              'purchaseOrder')
    FROM po_tab x;
```

Example 7–10 Validating XML Using Method ISSCHEMAVALID() in PL/SQL

```
DECLARE
  xml_instance XMLType;
BEGIN
  SELECT x.xmlcol INTO xml_instance FROM po_tab x WHERE id = 1;
  IF xml_instance.isSchemaValid('http://www.example.com/schemas/ipo.xsd') = 0
    THEN raise_application_error(-20500, 'Invalid Instance');
```

```
    ELSE DBMS_OUTPUT.put_line('Instance is valid');
  END IF;
END;
/
Instance is valid

PL/SQL procedure successfully completed.
```

XMLType method schemaValidate() can be used within INSERT and UPDATE triggers to ensure that all instances stored in the table are validated against the XML schema. Example 7–11 illustrates this.

Example 7–11 Validating XML Using Method SCHEMAVALIDATE() within Triggers

```
DROP TABLE po_tab;
CREATE TABLE po_tab OF XMLType
  XMLSCHEMA "http://www.example.com/schemas/ipo.xsd" ELEMENT "purchaseOrder";

CREATE TRIGGER emp_trig BEFORE INSERT OR UPDATE ON po_tab FOR EACH ROW

DECLARE
  newxml XMLType;
BEGIn
  newxml := :new.OBJECT_VALUE;
  XMLTYPE.schemavalidate(newxml);
END;
/
```

Example 7–12 uses Oracle SQL function XMLIsValid to do the following:

- Verify that the XMLType instance conforms to the specified XML schema
- Ensure that the incoming XML documents are valid by using CHECK constraints

Example 7–12 Checking XML Validity Using XMLISVALID Within CHECK Constraints

```
DROP TABLE po_tab;
CREATE TABLE po_tab OF XMLType
   (CHECK(XMLIsValid(OBJECT_VALUE) = 1))
   XMLSCHEMA "http://www.example.com/schemas/ipo.xsd" ELEMENT "purchaseOrder";
```

> **Note:** The validation functions and procedures described in section "Validation of XMLType Instances" facilitate validation checking. Of these, schemaValidate is the only one that raises errors that indicate why validation has failed.

Part III

Relational Data To and From XML Data

Part V of this manual introduces you to ways you can view your existing data as XML. It contains the following chapters:

8

Generation of XML Data from Relational Data

This chapter describes Oracle XML DB features for generating (constructing) XML data from relational data in the database. It describes the SQL/XML standard functions and Oracle Database-provided functions and packages for generating XML data from relational content.

This chapter contains these topics:

- Overview of Generating XML Data
- Generation of XML Data Using SQL Functions
- Generation of XML Data Using DBMS_XMLGEN
- SYS_XMLAGG Oracle SQL Function
- Guidelines for Generating XML with Oracle XML DB

> **See Also:** Chapter 4, "XQuery and Oracle XML DB" for information about constructing XML data using SQL/XML functions `XMLQuery` and `XMLTable`

Overview of Generating XML Data

You can generate XML data using Oracle XML DB in all of these ways:

- Use standard SQL/XML functions. See "Generation of XML Data Using SQL Functions" on page 8-2.
- Use Oracle SQL functions. See the following sections:
  - XMLROOT Oracle SQL Function on page 8-19
  - XMLCOLATTVAL Oracle SQL Function on page 8-19
  - XMLCDATA Oracle SQL Function on page 8-21
  - SYS_XMLAGG Oracle SQL Function on page 8-45. This operates on groups of rows, aggregating several XML documents into one.
- Use PL/SQL package `DBMS_XMLGEN`. See "Generation of XML Data Using DBMS_XMLGEN" on page 8-21.
- Use a `DBURIType` instance to construct XML documents from database data. See Chapter 33, "Data Access Using URIs".

See Also:

- Chapter 3, "Overview of How To Use Oracle XML DB"
- Chapter 7, "Transformation and Validation of XMLType Data"
- Chapter 11, "PL/SQL APIs for XMLType"
- Chapter 13, "Java DOM API for XMLType"

Generation of XML Data Using SQL Functions

This section describes SQL functions that you can use to construct XML data. Most of these functions belong to the SQL/XML standard.

- XMLELEMENT and XMLATTRIBUTES SQL/XML Functions on page 8-3
- XMLFOREST SQL/XML Function on page 8-9
- XMLCONCAT SQL/XML Function on page 8-11
- XMLAGG SQL/XML Function on page 8-12
- XMLPI SQL/XML Function on page 8-15
- XMLCOMMENT SQL/XML Function on page 8-16
- XMLSERIALIZE SQL/XML Function on page 8-16
- XMLPARSE SQL/XML Function on page 8-18

The standard XML-generation functions are also known as SQL/XML **publishing** or **generation** functions.

You can also construct XML data using the SQL/XML function `XMLQuery`. The use of `XMLQuery` is not limited to publishing XML data. It is very general and is referred to in this book as a SQL/XML *query and update* function.

Other XML-generating SQL functions presented in this section are Oracle-specific (not part of the SQL/XML standard):

- XMLROOT Oracle SQL Function on page 8-19.
- XMLCOLATTVAL Oracle SQL Function on page 8-19.
- XMLCDATA Oracle SQL Function on page 8-21.
- SYS_XMLAGG Oracle SQL Function on page 8-45. This operates on groups of relational rows, aggregating several XML documents into one.

All of the XML-generation SQL functions convert scalars and user-defined data-type instances to their canonical XML format. In this canonical mapping, user-defined data-type attributes are mapped to XML elements.

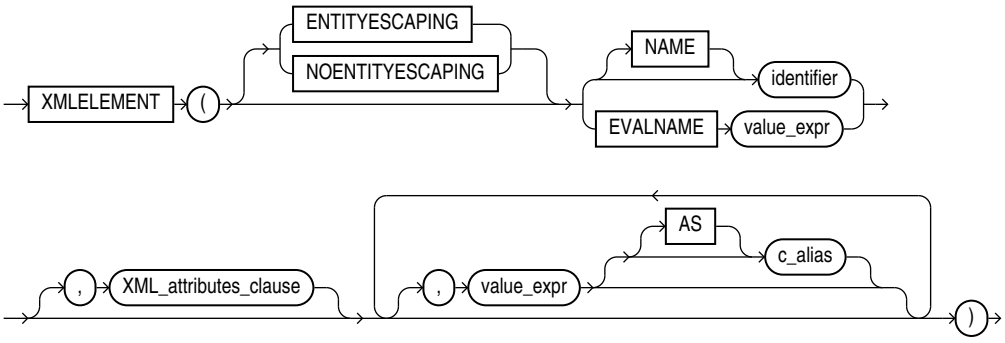
See Also:

- Chapter 4, "XQuery and Oracle XML DB" for information about constructing XML data using SQL/XML function `XMLQuery`
- *Oracle Database SQL Language Reference* for information about Oracle support for the SQL/XML standard

XMLELEMENT and XMLATTRIBUTES SQL/XML Functions

You use SQL/XML standard function `XMLElement` to construct XML elements from relational data. It takes as arguments an element name, an optional collection of attributes for the element, and zero or more additional arguments that make up the element content. It returns an `XMLType` instance.

Figure 8–1 XMLELEMENT Syntax



For an explanation of keywords `ENTITYESCAPING` and `NOENTITYESCAPING`, see "Escape of Characters in Generated XML Data" on page 8-5. These keywords are Oracle extensions to standard SQL/XML functions `XMLElement` and `XMLAttributes`.

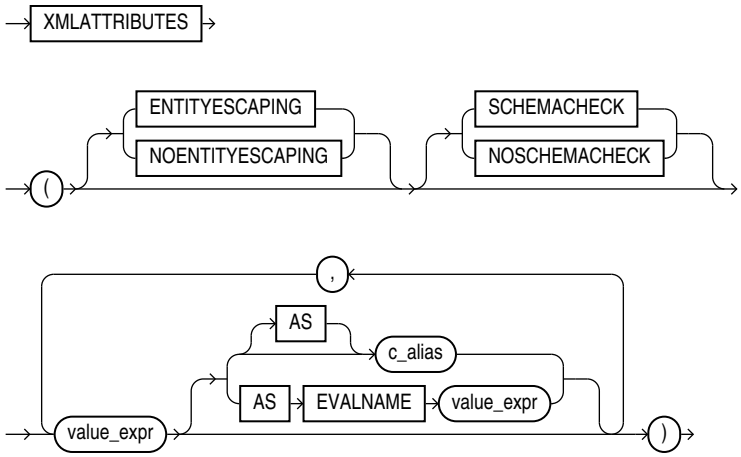
The first argument to function `XMLElement` defines an identifier that names the *root* XML element to be created. The root-element identifier argument can be defined using a literal identifier (*`identifier`*, in Figure 8–1) or by `EVALNAME` followed by an expression (*`value_expr`*) that evaluates to an identifier. However it is defined, the identifier must not be `NULL` or else an error is raised. The possibility of using `EVALNAME` is an Oracle extension to standard SQL/XML function `XMLElement`.

The optional *`XML-attributes-clause`* argument of function `XMLElement` specifies the attributes of the root element to be generated. Figure 8–2 shows the syntax of this argument.

In addition to the optional *`XML-attributes-clause`* argument, function `XMLElement` accepts zero or more *`value_expr`* arguments that make up the *content* of the root element (child elements and text content). If an *`XML-attributes-clause`* argument is also present then these content arguments must follow the *`XML-attributes-clause`* argument. Each of the content-argument expressions is evaluated, and the result is converted to XML format. If a value argument evaluates to `NULL`, then no content is created for that argument.

The optional *`XML-attributes-clause`* argument uses SQL/XML standard function `XMLAttributes` to specify the *attributes* of the root element. Function `XMLAttributes` can be used *only* in a call to function `XMLElement`. It cannot be used on its own.

Figure 8–2 XMLAttributes Clause Syntax (XMLATTRIBUTES)



For an explanation of keywords `ENTITYESCAPING` and `NOENTITYESCAPING`, see "Escape of Characters in Generated XML Data" on page 8-5. These keywords are Oracle extensions to standard SQL/XML functions `XMLElement` and `XMLAttributes`.

Keywords `SCHEMACHECK` and `NOSCHEMACHECK` determine whether or not a run-time check is made of the generated attributes, to see if any of them specify a schema location that corresponds to an XML schema that is registered with Oracle XML DB, and, if so, to try to generate XML schema-based XML data accordingly. The default behavior is that provided by `NOSCHEMACHECK`: no check is made. In releases prior to 12*c* Release 1 (12.1), the default behavior is to perform the check. Keyword `SCHEMACHECK` can be used to obtain backward compatibility.

Note that a similar check is *always* made at *compile* time, regardless of the presence or absence of `NOSCHEMACHECK`. This means, in particular, that if you use a string literal to specify an XML schema location attribute value, then a (compile-time) check is made, and, if appropriate, XML schema-based data is generated accordingly.

Keywords `SCHEMACHECK` and `NOSCHEMACHECK` are Oracle extensions to standard SQL/XML function `XMLAttributes`.

Note: If a view is created to generate XML data, function `XMLAttributes` is used to add XML-schema location references, and the target XML schema has not yet been registered with Oracle XML DB, then the XML data that is generated is not XML schema-based. If the XML schema is subsequently registered, then XML data that is generated thereafter is also *not* XML-schema-based. To create XML schema-based data, you must recompile the view.

Argument *`XML-attributes-clause`* itself contains one or more *`value_expr`* expressions as arguments to function `XMLAttributes`. These are evaluated to obtain the values for the attributes of the root element. (Do not confuse these *`value_expr`* arguments to function `XMLAttributes` with the *`value_expr`* arguments to function `XMLElement`, which specify the content of the root element.) The optional `AS` *`c_alias`* clause for each *`value_expr`* specifies that the attribute name is *`c_alias`*, which can be either a string literal or `EVALNAME` followed by an expression that evaluates to a string literal.

If an attribute value expression evaluates to `NULL`, then no corresponding attribute is created. The data type of an attribute value expression cannot be an object type or a collection.

Escape of Characters in Generated XML Data

As specified by the SQL/XML standard, characters in explicit *identifiers* are *not* escaped in any way – it is up to you to ensure that valid XML names are used. This applies to all SQL/XML functions. In particular, it applies to the root-element identifier of `XMLElement` (*`identifier`*, in Figure 8–1) and to attribute identifier aliases named with `AS` clauses of `XMLAttributes` (see Figure 8–2).

However, other XML data that is generated is *escaped*, by default, to ensure that only valid XML `NameChar` characters are generated. As part of generating a valid XML element or attribute name from a SQL identifier, each character that is disallowed in an XML name is replaced with an underscore character (_), followed by the hexadecimal Unicode representation of the original character, followed by a second underscore character. For example, the colon character (`:`) is escaped by replacing it with `_003A_`, where 003A is the hexadecimal Unicode representation.

Escaping applies to characters in the evaluated *`value_expr`* arguments to *all* SQL/XML functions, including `XMLElement` and `XMLAttributes`. It applies also to the characters of an attribute identifier that is defined implicitly from an `XMLAttributes` attribute value expression that is *not* followed by an `AS` clause: the escaped form of the SQL column name is used as the name of the attribute.

In some cases, you might not need or want character escaping. If you know, for example, that the XML data being generated is well-formed, then you can save some processing time by inhibiting escaping. You can do that by specifying the keyword `NOENTITYESCAPING` for SQL/XML functions `XMLElement` and `XMLAttributes`. Keyword `ENTITYESCAPING` imposes escaping, which is the default behavior. Keywords `NOENTITYESCAPING` and `ENTITYESCAPING` are Oracle extensions to standard SQL/XML functions `XMLElement` and `XMLAttributes`.

Formatting of XML Dates and Timestamps

The XML Schema standard specifies that dates and timestamps in XML data be in standard formats. XML generation functions in Oracle XML DB produce XML dates and timestamps according to this standard.

In releases prior to Oracle Database 10g Release 2, the database settings for date and timestamp formats, not the XML Schema standard formats, were used for XML. You can reproduce this *previous* behavior by setting the database event 19119, level 0x8, as follows:

```
ALTER SESSION SET EVENTS '19119 TRACE NAME CONTEXT FOREVER, LEVEL 0x8';
```

If you must otherwise produce a non-standard XML date or timestamp, use SQL function `to_char` – see Example 8–1.

> **See Also:**
>
> `http://www.w3.org/TR/2004/REC-xmlschema-2-20041028/datatypes.html#isoformats` for the XML Schema specification of XML date and timestamp formats

XMLElement Examples

This section provides examples that use SQL/XML function `XMLElement`.

Example 8–1 uses `XMLElement` to generate an XML date with a format that is different from the XML Schema standard date format.

Example 8–1 XMLELEMENT: Formatting a Date

```
-- With standard XML date format:
SELECT XMLElement("Date", hire_date)
  FROM hr.employees
  WHERE employee_id = 203;

XMLELEMENT("DATE",HIRE_DATE)
----------------------------
<Date>2002-06-07</Date>

1 row selected.

-- With an alternative date format:
SELECT XMLElement("Date", to_char(hire_date))
  FROM hr.employees
  WHERE employee_id = 203;

XMLELEMENT("DATE",TO_CHAR(HIRE_DATE))
-------------------------------------
<Date>07-JUN-02</Date>

1 row selected.
```

Example 8–2 uses `XMLElement` to generate an `Emp` element for each employee, with the employee name as the content.

Example 8–2 XMLELEMENT: Generating an Element for Each Employee

```
SELECT e.employee_id,
       XMLELEMENT ("Emp", e.first_name ||' '|| e.last_name) AS "RESULT"
   FROM hr.employees e
   WHERE employee_id > 200;
```

This query produces the following typical result:

```
EMPLOYEE_ID RESULT
----------- ---------------------------------
        201 <Emp>Michael Hartstein</Emp>
        202 <Emp>Pat Fay</Emp>
        203 <Emp>Susan Mavris</Emp>
        204 <Emp>Hermann Baer</Emp>
        205 <Emp>Shelley Higgins</Emp>
        206 <Emp>William Gietz</Emp>

6 rows selected.
```

SQL/XML function `XMLElement` can also be nested, to produce XML data with a nested structure.

Example 8–3 uses `XMLElement` to generate an `Emp` element for each employee, with child elements that provide the employee name and hire date.

Example 8–3 XMLELEMENT: Generating Nested XML

```
SELECT XMLElement("Emp",
                  XMLElement("name", e.first_name ||' '|| e.last_name),
                  XMLElement("hiredate", e.hire_date)) AS "RESULT"
FROM hr.employees e
WHERE employee_id > 200;
```

This query produces the following typical XML result:

```
RESULT
--------------------------------------------------------------------------
<Emp><name>Michael Hartstein</name><hiredate>2004-02-17</hiredate></Emp>
<Emp><name>Pat Fay</name><hiredate>2005-08-17</hiredate></Emp>
<Emp><name>Susan Mavris</name><hiredate>2002-06-07</hiredate></Emp>
<Emp><name>Hermann Baer</name><hiredate>2002-06-07</hiredate></Emp>
<Emp><name>Shelley Higgins</name><hiredate>2002-06-07</hiredate></Emp>
<Emp><name>William Gietz</name><hiredate>2002-06-07</hiredate></Emp>

6 rows selected.
```

Example 8–4 uses `XMLElement` to generate an `Emp` element for each employee, with attributes `id` and `name`.

Example 8–4 XMLELEMENT: Generating Employee Elements with Attributes ID and Name

```
SELECT XMLElement("Emp", XMLAttributes(
                           e.employee_id as "ID",
                           e.first_name ||' ' || e.last_name AS "name"))
  AS "RESULT"
  FROM hr.employees e
  WHERE employee_id > 200;
```

This query produces the following typical XML result fragment:

```
RESULT
-----------------------------------------------
<Emp ID="201" name="Michael Hartstein"></Emp>
<Emp ID="202" name="Pat Fay"></Emp>
<Emp ID="203" name="Susan Mavris"></Emp>
<Emp ID="204" name="Hermann Baer"></Emp>
<Emp ID="205" name="Shelley Higgins"></Emp>
<Emp ID="206" name="William Gietz"></Emp>

6 rows selected.
```

As mentioned in "Escape of Characters in Generated XML Data" on page 8-5, characters in the root-element name and the names of any attributes defined by `AS` clauses are *not* escaped. Characters in an identifier name are escaped only if the name is created from an evaluated expression (such as a column reference).

Example 8–5 shows that, with XML data constructed using `XMLElement`, the root-element name and the attribute name are *not* escaped. Invalid XML is produced because greater-than sign (>) and a comma (,) are not allowed in XML element and attribute names.

Example 8–5 XMLELEMENT: Characters in Generated XML Data Are Not Escaped

```
SELECT XMLElement("Emp->Special",
                  XMLAttributes(e.last_name || ', ' || e.first_name
                                AS "Last,First"))
   AS "RESULT"
   FROM hr.employees e
   WHERE employee_id = 201;
```

This query produces the following result, which is *not* well-formed XML:

```
RESULT
```

```
--------------------------------------------------------------------
<Emp->Special Last,First="Hartstein, Michael"></Emp->Special>

1 row selected.
```

A full description of character escaping is included in the SQL/XML standard.

Example 8–6 illustrates the use of namespaces to create an XML schema-based document. Assuming that an XML schema "http://www.oracle.com/Employee.xsd" exists and has no target namespace, the query in Example 8–6 creates an XMLType instance conforming to that schema:

Example 8–6 Creating a Schema-Based XML Document Using XMLELEMENT with Namespaces

```
SELECT XMLElement("Employee",
                  XMLAttributes('http://www.w3.org/2001/XMLSchema' AS
                                  "xmlns:xsi",
                                'http://www.oracle.com/Employee.xsd' AS
                                  "xsi:nonamespaceSchemaLocation"),
                  XMLForest(employee_id, last_name, salary)) AS "RESULT"
   FROM hr.employees
   WHERE department_id = 10;
```

This creates the following XML document that conforms to XML schema Employee.xsd. (The result is shown here pretty-printed, for clarity.)

```
RESULT
--------------------------------------------------------------------------------
<Employee xmlns:xsi="http://www.w3.org/2001/XMLSchema"
          xsi:nonamespaceSchemaLocation="http://www.oracle.com/Employee.xsd">
   <EMPLOYEE_ID>200</EMPLOYEE_ID>
   <LAST_NAME>Whalen</LAST_NAME>
   <SALARY>4400</SALARY>
</Employee>

1 row selected.
```

Example 8–7 uses XMLElement to generate an XML document with employee and department information, using data from sample database schema table hr.departments.

Example 8–7 XMLELEMENT: Generating an Element from a User-Defined Data-Type Instance

```
CREATE OR REPLACE TYPE emp_t AS OBJECT ("@EMPNO" NUMBER(4),
                                        ENAME VARCHAR2(10));

CREATE OR REPLACE TYPE emplist_t AS TABLE OF emp_t;

CREATE OR REPLACE TYPE dept_t AS OBJECT ("@DEPTNO" NUMBER(2),
                                         DNAME VARCHAR2(14),
                                         EMP_LIST emplist_t);

SELECT XMLElement("Department",
                  dept_t(department_id,
                         department_name,
                         cast(MULTISET
                              (SELECT employee_id, last_name
                                 FROM hr.employees e
                                 WHERE e.department_id = d.department_id)
```

```
                                AS emplist_t)))
  AS deptxml
  FROM hr.departments d
  WHERE d.department_id = 10;
```

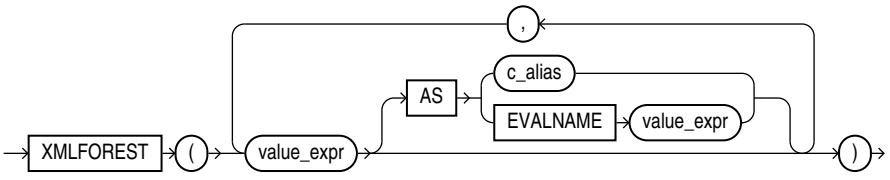
This produces an XML document which contains the `Department` element and the canonical mapping of type `dept_t`.

```
DEPTXML
-------------
<Department>
  <DEPT_T DEPTNO="10">
    <DNAME>ACCOUNTING</DNAME>
    <EMPLIST>
      <EMP_T EMPNO="7782">
        <ENAME>CLARK</ENAME>
      </EMP_T>
      <EMP_T EMPNO="7839">
        <ENAME>KING</ENAME>
      </EMP_T>
      <EMP_T EMPNO="7934">
        <ENAME>MILLER</ENAME>
      </EMP_T>
    </EMPLIST>
  </DEPT_T>
</Department>

1 row selected.
```

XMLFOREST SQL/XML Function

You use SQL/XML standard function `XMLForest` to construct a forest of XML elements. Its arguments are expressions to be evaluated, with optional aliases. Figure 8–3 describes the `XMLForest` syntax.

Figure 8–3 XMLFOREST Syntax



Each of the value expressions (*value_expr* in Figure 8–3) is converted to XML format, and, optionally, identifier *c_alias* is used as the attribute identifier (*c_alias* can be a string literal or `EVALNAME` followed by an expression that evaluates to a string literal). The possibility of using `EVALNAME` is an Oracle extension to standard SQL/XML function `XMLForest`.

For an object type or collection, the `AS` clause is required. For other types, the `AS` clause is optional. For a given expression, if the `AS` clause is omitted, then characters in the evaluated value expression are *escaped* to form the name of the enclosing tag of the element. The escaping is as defined in "Escape of Characters in Generated XML Data" on page 8-5. If the value expression evaluates to `NULL`, then no element is created for that expression.

Example 8–8 uses XMLElement and XMLForest to generate an Emp element for each employee, with a name attribute and with child elements containing the employee hire date and department as the content.

Example 8–8 XMLFOREST: Generating Elements with Attribute and Child Elements

```
SELECT XMLElement("Emp",
                  XMLAttributes(e.first_name ||' '|| e.last_name AS "name"),
                  XMLForest(e.hire_date, e.department AS "department"))
AS "RESULT"
FROM employees e WHERE e.department_id = 20;
```

(The WHERE clause is used here to keep the example brief.) This query produces the following XML result:

```
RESULT
-------------------------------------
<Emp name="Michael Hartstein">
  <HIRE_DATE>2004-02-17</HIRE_DATE>
  <department>20</department>
</Emp>
<Emp name="Pat Fay">
  <HIRE_DATE>2005-08-17</HIRE_DATE>
  <department>20</department>
</Emp>

2 rows selected.
```

> **See Also:** Example 8–20, "XMLCOLATTVAL: Generating Elements with Attribute and Child Elements"

Example 8–9 uses XMLForest to generate hierarchical XML data from user-defined data-type instances.

Example 8–9 XMLFOREST: Generating an Element from a User-Defined Data-Type Instance

```
SELECT XMLForest(
  dept_t(department_id,
         department_name,
         cast(MULTISET
              (SELECT employee_id, last_name
                 FROM hr.employees e WHERE e.department_id = d.department_id)
              AS emplist_t))
         AS "Department")
  AS deptxml
  FROM hr.departments d
  WHERE department_id=10;
```

This produces an XML document with element Department containing attribute DEPTNO and child element DNAME.

```
DEPTXML
---------------------------------
<Department DEPTNO="10">
  <DNAME>Administration</DNAME>
    <EMP_LIST>
      <EMP_T EMPNO="200">
        <ENAME>Whalen</ENAME>
      </EMP_T>
```

```
    </EMP_LIST>
</Department>

1 row selected.
```

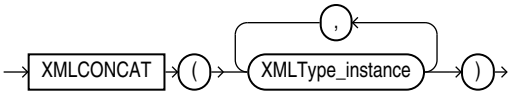
You may want to compare this example with Example 8–7 and Example 8–25.

XMLCONCAT SQL/XML Function

You use SQL/XML standard function `XMLConcat` to construct an XML fragment by concatenating multiple `XMLType` instances. Figure 8–4 shows the `XMLConcat` syntax. Function `XMLConcat` has two forms:

- The first form takes as argument an `XMLSequenceType` value, which is a varray of `XMLType` instances, and returns a single `XMLType` instance that is the concatenation of all of the elements of the varray. This form is useful to collapse lists of `XMLType` instances into a single instance.
- The second form takes an arbitrary number of `XMLType` instances and concatenates them together. If one of the values is `NULL`, then it is ignored in the result. If all the values are `NULL`, then the result is `NULL`. This form is used to concatenate arbitrary number of `XMLType` instances in the same row. Function `XMLAgg` can be used to concatenate `XMLType` instances across rows.

Figure 8–4 XMLCONCAT Syntax



Example 8–10 uses SQL/XML function `XMLConcat` to return a concatenation of `XMLType` instances from an `XMLSequenceType` value (a varray of `XMLType` instances).

Example 8–10 XMLCONCAT: Concatenating XMLType Instances from a Sequence

```
SELECT XMLSerialize(
         CONTENT
         XMLConcat(XMLSequenceType(
                   XMLType('<PartNo>1236</PartNo>'),
                   XMLType('<PartName>Widget</PartName>'),
                   XMLType('<PartPrice>29.99</PartPrice>')))
         AS CLOB)
  AS "RESULT"
  FROM DUAL;
```

This query returns a single XML fragment. (The result is shown here pretty-printed, for clarity.)

```
RESULT
---------------
<PartNo>1236</PartNo>
<PartName>Widget</PartName>
<PartPrice>29.99</PartPrice>

1 row selected.
```

Example 8–11 uses `XMLConcat` to create and concatenate XML elements for employee first and the last names.

Example 8–11 XMLCONCAT: Concatenating XML Elements

```
SELECT XMLConcat(XMLElement("first", e.first_name),
                 XMLElement("last", e.last_name))
  AS "RESULT"
  FROM employees e;
```

This query produces the following XML fragment:

```
RESULT
-----------------------------------------
<first>Den</first><last>Raphaely</last>
<first>Alexander</first><last>Khoo</last>
<first>Shelli</first><last>Baida</last>
<first>Sigal</first><last>Tobias</last>
<first>Guy</first><last>Himuro</last>
<first>Karen</first><last>Colmenares</last>

6 rows selected.
```

XMLAGG SQL/XML Function

You use SQL/XML standard function `XMLAgg` to construct a forest of XML elements from a collection of XML elements—it is an aggregate function.

Figure 8–5 XMLAGG Syntax

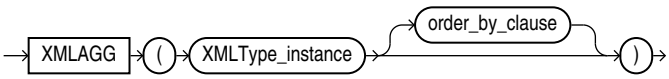


Figure 8–5 describes the `XMLAgg` syntax, where the `order_by_clause` is the following:

```
ORDER BY [list of: expr [ASC|DESC] [NULLS {FIRST|LAST}]]
```

Numeric literals are *not* interpreted as column positions. For example, `ORDER BY 1` does not mean order by the first column. Instead, numeric literals are interpreted as any other literals.

As with SQL/XML function `XMLConcat`, any arguments whose value is `NULL` are dropped from the result. SQL/XML function `XMLAgg` is similar to Oracle SQL function `sys_XMLAgg`, but `XMLAgg` returns a forest of nodes and it does not accept an `XMLFormat` parameter.

SQL/XML function `XMLAgg` can be used to concatenate `XMLType` instances across *multiple rows*. It also accepts an optional `ORDER BY` clause, to order the XML values being aggregated. Function `XMLAgg` produces one aggregated XML result for each group. If there is no group by specified in the query, then it returns a single aggregated XML result for all the rows of the query.

Example 8–12 uses SQL/XML functions `XMLAgg` and `XMLElement` to construct a `Department` element that contains `Employee` elements that have employee job ID and last name as their contents. It also orders the `Employee` elements in the department by employee last name. (The result is shown pretty-printed, for clarity.)

Example 8–12 XMLAGG: Generating a Department Element with Child Employee Elements

```
SELECT XMLElement("Department", XMLAgg(XMLElement("Employee",
                                                  e.job_id||' '||e.last_name)
                                       ORDER BY e.last_name))
```

```
  AS "Dept_list"
  FROM hr.employees e
  WHERE e.department_id = 30 OR e.department_id = 40;

Dept_list
------------------
<Department>
  <Employee>PU_CLERK Baida</Employee>
  <Employee>PU_CLERK Colmenares</Employee>
  <Employee>PU_CLERK Himuro</Employee>
  <Employee>PU_CLERK Khoo</Employee>
  <Employee>HR_REP Mavris</Employee>
  <Employee>PU_MAN Raphaely</Employee>
  <Employee>PU_CLERK Tobias</Employee>
</Department>

1 row selected.
```

The result is a *single* row, because `XMLAgg` aggregates the employee rows.

Example 8–13 shows how to use the `GROUP BY` clause to group the returned set of rows into multiple groups, forming multiple `Department` elements. (The result is shown here pretty-printed, for clarity.)

Example 8–13 XMLAGG: Using GROUP BY to Generate Multiple Department Elements

```
SELECT XMLElement("Department", XMLAttributes(department_id AS "deptno"),
                  XMLAgg(XMLElement("Employee", e.job_id||' '||e.last_name)))
   AS "Dept_list"
   FROM hr.employees e
   GROUP BY e.department_id;

Dept_list
------------------
<Department deptno="30">
  <Employee>PU_MAN Raphaely</Employee>
  <Employee>PU_CLERK Colmenares</Employee>
  <Employee>PU_CLERK Himuro</Employee>
  <Employee>PU_CLERK Tobias</Employee>
  <Employee>PU_CLERK Baida</Employee>
  <Employee>PU_CLERK Khoo</Employee></Department>

<Department deptno="40">
  <Employee>HR_REP Mavris</Employee>
</Department>

2 rows selected.
```

You can order the employees within each department by using the `ORDER BY` clause inside the `XMLAgg` expression.

> **Note:** Within the `ORDER BY` clause, Oracle Database does not interpret number literals as column positions, as it does in other uses of this clause.

Function `XMLAgg` can be used to reflect the hierarchical nature of some relationships that exist in tables. Example 8–14 generates a department element for department 30. Within this element is a child element `emp` for each employee of the department.

Within each employee element is a `dependent` element for each dependent of that employee.

Example 8–14 XMLAGG: Generating Nested Elements

```
SELECT last_name, employee_id FROM employees WHERE department_id = 30;

LAST_NAME                 EMPLOYEE_ID
------------------------- -----------
Raphaely                          114
Khoo                              115
Baida                             116
Tobias                            117
Himuro                            118
Colmenares                        119

6 rows selected.
```

A `dependents` table holds the dependents of each employee.

```
CREATE TABLE hr.dependents (id NUMBER(4) PRIMARY KEY,
                            employee_id NUMBER(4),
                            name VARCHAR2(10));
Table created.
INSERT INTO dependents VALUES (1, 114, 'MARK');
1 row created.
INSERT INTO dependents VALUES (2, 114, 'JACK');
1 row created.
INSERT INTO dependents VALUES (3, 115, 'JANE');
1 row created.
INSERT INTO dependents VALUES (4, 116, 'HELEN');
1 row created.
INSERT INTO dependents VALUES (5, 116, 'FRANK');
1 row created.
COMMIT;
Commit complete.
```

The following query generates the XML data for a department that contains the information about dependents. (The result is shown here pretty-printed, for clarity.)

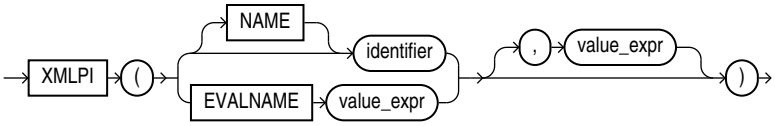
```
SELECT
  XMLElement(
    "Department",
    XMLAttributes(d.department_name AS "name"),
    (SELECT
       XMLAgg(XMLElement("emp",
                         XMLAttributes(e.last_name AS name),
                         (SELECT XMLAgg(XMLElement("dependent",
                                                   XMLAttributes(de.name AS "name")))
                            FROM dependents de
                            WHERE de.employee_id = e.employee_id)))
       FROM employees e
       WHERE e.department_id = d.department_id)) AS "dept_list"
  FROM departments d
  WHERE department_id = 30;

dept_list
--------------------------------------------------------------------------------
<Department name="Purchasing">
  <emp NAME="Raphaely">
    <dependent name="MARK"></dependent>
```

```
    <dependent name="JACK"></dependent>
  </emp><emp NAME="Khoo">
    <dependent name="JANE"></dependent>
  </emp>
  <emp NAME="Baida">
    <dependent name="HELEN"></dependent>
    <dependent name="FRANK"></dependent>
  </emp><emp NAME="Tobias"></emp>
  <emp NAME="Himuro"></emp>
  <emp NAME="Colmenares"></emp>
</Department>

1 row selected.
```

XMLPI SQL/XML Function

You use SQL/XML standard function `XMLPI` to construct an XML processing instruction (PI). Figure 8–6 shows the syntax:

Figure 8–6 XMLPI Syntax



Argument *value_expr* is evaluated, and the string result is appended to the optional identifier (*identifier*), separated by a space. This concatenation is then enclosed between "<?" and "?>" to create the processing instruction. That is, if *string-result* is the result of evaluating *value_expr*, then the generated processing instruction is <?*identifier string-result*?>. If *string-result* is the empty string, '', then the function returns <?*identifier*?>.

As an alternative to using keyword `NAME` followed by a *literal* string *identifier*, you can use keyword `EVALNAME` followed by an expression that evaluates to a string to be used as the identifier. The possibility of using `EVALNAME` is an Oracle extension to standard SQL/XML function `XMLPI`.

An error is raised if the constructed XML is not a legal XML processing instruction. In particular:

- *identifier* must *not* be the word "xml" (uppercase, lowercase, or mixed case).
- *string-result* must *not* contain the character sequence "?>".

Function `XMLPI` returns an instance of `XMLType`. If *string-result* is `NULL`, then it returns `NULL`.

Example 8–15 uses `XMLPI` to generate a simple processing instruction.

Example 8–15 Using SQL/XML Function XMLPI

```
SELECT XMLPI(NAME "OrderAnalysisComp", 'imported, reconfigured, disassembled')
  AS pi FROM DUAL;
```

This results in the following output:

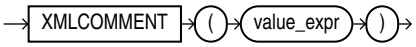
```
PI
------------------------------------------------------------
<?OrderAnalysisComp imported, reconfigured, disassembled?>
```

```
1 row selected.
```

XMLCOMMENT SQL/XML Function

You use SQL/XML standard function `XMLComment` to construct an XML comment. Figure 8–7 shows the syntax:

Figure 8–7 XMLComment Syntax



Argument *value_expr* is evaluated to a string, and the result is used as the body of the generated XML comment. The result is thus `<!--`*string-result*`-->`, where *string-result* is the string result of evaluating *value_expr*. If *string-result* is the empty string, then the comment is empty: `<!---->`.

An error is raised if the constructed XML is not a legal XML comment. In particular, *string-result* must *not* contain two consecutive hyphens (-): "--".

Function `XMLComment` returns an instance of `XMLType`. If *string-result* is `NULL`, then the function returns `NULL`.

Example 8–16 uses `XMLComment` to generate a simple XML comment.

Example 8–16 Using SQL/XML Function XMLCOMMENT

```
SELECT XMLComment('This is a comment') AS cmnt FROM DUAL;
```

This query results in the following output:

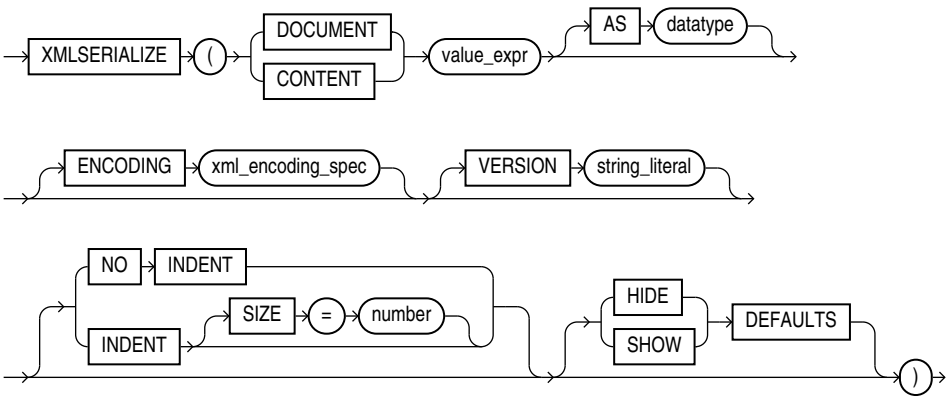
```
CMNT
--------------------------
<!--This is a comment-->
```

XMLSERIALIZE SQL/XML Function

You use SQL/XML standard function `XMLSerialize` to obtain a string or LOB representation of XML data.

Figure 8–8 shows the syntax of `XMLSerialize`:

Figure 8–8 XMLSerialize Syntax



Argument *value_expr* is evaluated, and the resulting XMLType instance is serialized to produce the content of the created string or LOB. If present[1], the specified *datatype* must be one of the following (the default data type is CLOB):

- VARCHAR2(*N*), where *N* is the size in bytes[2]
- CLOB
- BLOB

If you specify DOCUMENT, then the result of evaluating *value_expr* must be a well-formed document. In particular, it must have a single root. If the result is not a well-formed document, then an error is raised. If you specify CONTENT, however, then the result of *value_expr* is *not* checked for being well-formed.

If *value_expr* evaluates to NULL or to the empty string (''), then function XMLSerialize returns NULL.

The ENCODING clause specifies the character encoding for XML data that is serialized as a BLOB instance. *xml_encoding_spec* is an XML encoding declaration (encoding="..."). If *datatype* is BLOB and you specify an ENCODING clause, then the output is encoded as specified, and *xml_encoding_spec* is added to the prolog to indicate the BLOB encoding. If you specify an ENCODING clause with a *datatype* other than BLOB, then an error is raised. For UTF-16 characters, *xml_encoding_spec* must be one of the following:

- encoding=UTF-16BE – Big-endian UTF-16 encoding
- encoding=UTF-16LE – Little-endian UTF-16 encoding

If you specify VERSION then the specified version is used in the XML declaration (<?xml version="..." ...?>).

If you specify NO INDENT, then all insignificant whitespace is stripped, so that it does not appear in the output. If you specify INDENT SIZE = *N*, where *N* is a whole number, then the output is *pretty-printed* using a relative indentation of *N* spaces. If *N* is 0, then pretty-printing inserts a newline character after each element, placing each element on a line by itself, but there is no other insignificant whitespace in the output. If you specify INDENT without a SIZE specification, then 2-space indenting is used. If you specify neither NO INDENT nor INDENT, then the behavior (pretty-printing or not) is indeterminate.

HIDE DEFAULTS and SHOW DEFAULTS apply only to XML schema-based data. If you specify SHOW DEFAULTS and the input data is missing any optional elements or attributes for which the XML schema defines default values, then those elements or attributes are included in the output with their default values. If you specify HIDE DEFAULTS, then no such elements or attributes are included in the output. HIDE DEFAULTS is the default behavior.

Example 8–17 uses XMLSerialize to produce a CLOB instance containing serialized XML data.

Example 8–17 Using SQL/XML Function XMLSERIALIZE

```
SELECT XMLSerialize(DOCUMENT XMLType('<poid>143598</poid>') AS CLOB)
  AS xmlserialize_doc FROM DUAL;
```

[1] The SQL/XML standard requires argument *data-type* to be present, but it is *optional* in the Oracle XML DB implementation of the standard, for ease of use.

[2] The limit is 32767 or 4000 bytes, depending on the value of initialization parameter MAX_STRING_SIZE. See *Oracle Database SQL Language Reference*.

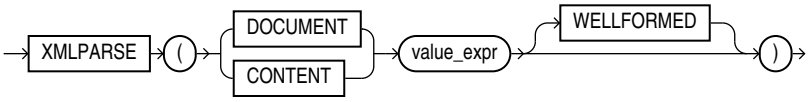
This results in the following output:

```
XMLSERIALIZE_DOC
------------------
<poid>143598</poid>
```

XMLPARSE SQL/XML Function

You use SQL/XML standard function `XMLParse` to parse a string containing XML data and construct a corresponding `XMLType` instance. Figure 8–9 shows the syntax:

Figure 8–9 XMLParse Syntax



Argument *value_expr* is evaluated to produce the string that is parsed. If you specify `DOCUMENT`, then *value_expr* must correspond to a *singly rooted*, well-formed XML document. If you specify `CONTENT`, then *value_expr* need only correspond to a well-formed XML fragment (it need not be singly rooted).

Keyword `WELLFORMED` is an Oracle XML DB extension to the SQL/XML standard. When you specify `WELLFORMED`, you are informing the parser that argument *value_expr* is well-formed, so Oracle XML DB does *not* check to ensure that it is well-formed.

Function `XMLParse` returns an instance of `XMLType`. If *value_expr* evaluates to `NULL`, then the function returns `NULL`.

Example 8–18 uses `XMLParse` to parse a string of XML code and produce an `XMLType` instance.

Example 8–18 Using SQL/XML Function XMLPARSE

```
SELECT XMLParse(CONTENT
                '124 <purchaseOrder poNo="12435">
                       <customerName> Acme Enterprises</customerName>
                       <itemNo>32987457</itemNo>
                     </purchaseOrder>'
                WELLFORMED)
  AS po FROM DUAL d;
```

This results in the following output:

```
PO
--------------------------------------------
124 <purchaseOrder poNo="12435">
<customerName>Acme Enterprises</customerName>
<itemNo>32987457</itemNo>
</purchaseOrder>
```

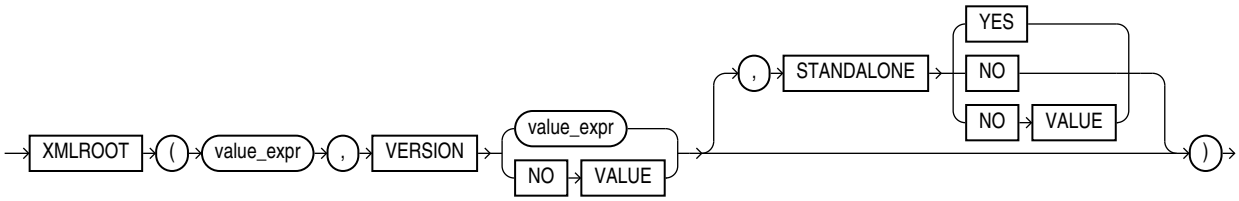
> **See Also:** `http://www.w3.org/TR/REC-xml/`, *Extensible Markup Language (XML) 1.0*, for the definition of well-formed XML documents and fragments

XMLROOT Oracle SQL Function

Oracle SQL function `XMLRoot` was at one time part of the SQL/XML standard, but it is *deprecated* as a standard function as of SQL/XML 2005. It remains available in Oracle XML DB, as an Oracle SQL function.

You use `XMLRoot` to add a `VERSION` property, and optionally a `STANDALONE` property, to the root information item of an XML value. Typically, this is done to ensure data-model compliance. Figure 8–10 shows the syntax of `XMLRoot`:

Figure 8–10 XMLRoot Syntax



The first argument, *xml-expression*, is evaluated, and the indicated properties (`VERSION`, `STANDALONE`) and their values are added to a new prolog for the resulting `XMLType` instance. If the evaluated *xml-expression* already contains a prolog, then an error is raised.

Second argument *string-valued-expression* (which follows keyword `VERSION`) is evaluated, and the resulting string is used as the value of the prolog `version` property. The value of the prolog `standalone` property (lowercase) is taken from the optional third argument `STANDALONE YES` or `NO` value. If `NOVALUE` is used for `VERSION`, then `"version=1.0"` is used in the resulting prolog. If `NOVALUE` is used for `STANDALONE`, then the `standalone` property is omitted from the resulting prolog.

Function `XMLRoot` returns an instance of `XMLType`. If first argument *xml-expression* evaluates to `NULL`, then the function returns `NULL`.

Example 8–19 uses `XMLRoot` to add an XML declaration with `version` and `standalone` attributes.

Example 8–19 Using Oracle SQL Function XMLRoot

```
SELECT XMLRoot(XMLType('<poid>143598</poid>'), VERSION '1.0', STANDALONE YES)
  AS xmlroot FROM DUAL;
```

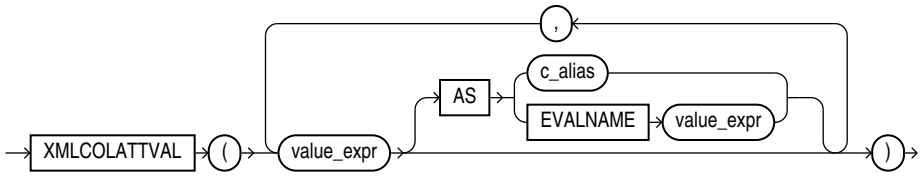
This results in the following output:

```
XMLROOT
--------------------------------------
<?xml version="1.0" standalone="yes"?>
<poid>143598</poid>

1 row selected.
```

XMLCOLATTVAL Oracle SQL Function

Oracle SQL function `XMLColAttVal` generates a forest of XML `column` elements containing the values of the arguments passed in. This function is an Oracle extension to the SQL/XML ANSI-ISO standard functions. Figure 8–11 shows the `XMLColAttVal` syntax.

Figure 8–11 XMLCOLATTVAL Syntax



The arguments are used as the values of the `name` attribute of the `column` element. The *`c_alias`* values are used as the attribute identifiers.

As an alternative to using keyword `AS` followed by a *literal* string *`c_alias`*, you can use `AS EVALNAME` followed by an expression that evaluates to a string to be used as the attribute identifier.

Because argument values *`value_expr`* are used only as attribute *values*, they need *not* be escaped in any way. This is in contrast to function `XMLForest`. It means that you can use `XMLColAttVal` to transport SQL columns and values without escaping.

Example 8–20 uses `XMLColAttVal` to generate an `Emp` element for each employee, with a `name` attribute, and with `column` elements that have the employee hire date and department as the content.

Example 8–20 XMLCOLATTVAL: Generating Elements with Attribute and Child Elements

```
SELECT XMLElement("Emp",
                  XMLAttributes(e.first_name ||' '||e.last_name AS "fullname" ),
                  XMLColAttVal(e.hire_date, e.department_id AS "department"))
  AS "RESULT"
  FROM hr.employees e
  WHERE e.department_id = 30;
```

This query produces the following XML result. (The result is shown here pretty-printed, for clarity.)

```
RESULT
------------------------------------------------------------
<Emp fullname="Den Raphaely">
  <column name = "HIRE_DATE">2002-12-07</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Alexander Khoo">
  <column name = "HIRE_DATE">2003-05-18</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Shelli Baida">
  <column name = "HIRE_DATE">2005-12-24</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Sigal Tobias">
  <column name = "HIRE_DATE">2005-07-24</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Guy Himuro">
  <column name = "HIRE_DATE">2006-11-15</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Karen Colmenares">
  <column name = "HIRE_DATE">2007-08-10</column>
  <column name = "department">30</column>
```

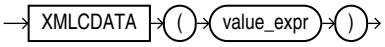
```
</Emp>

6 rows selected.
```

> **See Also:** Example 8–8, "XMLFOREST: Generating Elements with Attribute and Child Elements"

XMLCDATA Oracle SQL Function

You use Oracle SQL function `XMLCDATA` to generate an XML `CDATA` section. Figure 8–12 shows the syntax:

Figure 8–12 XMLCDATA Syntax



Argument *value_expr* is evaluated to a string, and the result is used as the body of the generated XML `CDATA` section, `<![CDATA[`*string-result*`]>`, where *string-result* is the result of evaluating *value_expr*. If *string-result* is the empty string, then the `CDATA` section is empty: `<![CDATA[]>`.

An error is raised if the constructed XML is not a legal XML `CDATA` section. In particular, *string-result* must *not* contain two consecutive right brackets (`]`): "`]]`".

Function `XMLCDATA` returns an instance of `XMLType`. If *string-result* is `NULL`, then the function returns `NULL`.

Example 8–21 uses `XMLCDATA` to generate an XML `CDATA` section.

Example 8–21 Using Oracle SQL Function XMLCDATA

```
SELECT XMLElement("PurchaseOrder",
                  XMLElement("Address",
                             XMLCDATA('100 Pennsylvania Ave.'),
                             XMLElement("City", 'Washington, D.C.')))
  AS RESULT FROM DUAL;
```

This results in the following output. (The result is shown here pretty-printed, for clarity.)

```
RESULT
--------------------------
<PurchaseOrder>
  <Address>
    <![CDATA[100 Pennsylvania Ave.]>
    <City>Washington, D.C.</City>
  </Address>
</PurchaseOrder>
```

Generation of XML Data Using DBMS_XMLGEN

PL/SQL package `DBMS_XMLGEN` creates XML documents from SQL query results. It retrieves an XML document as a `CLOB` or `XMLType` value.

It provides a *fetch* interface, whereby you can specify the maximum number of rows to retrieve and the number of rows to skip. For example, the first fetch could retrieve a maximum of ten rows, skipping the first four. This is especially useful for pagination requirements in Web applications.

Package DBMS_XMLGEN also provides options for changing tag names for ROW, ROWSET, and so on. The parameters of the package can restrict the number of rows retrieved and the enclosing tag names.

See Also:

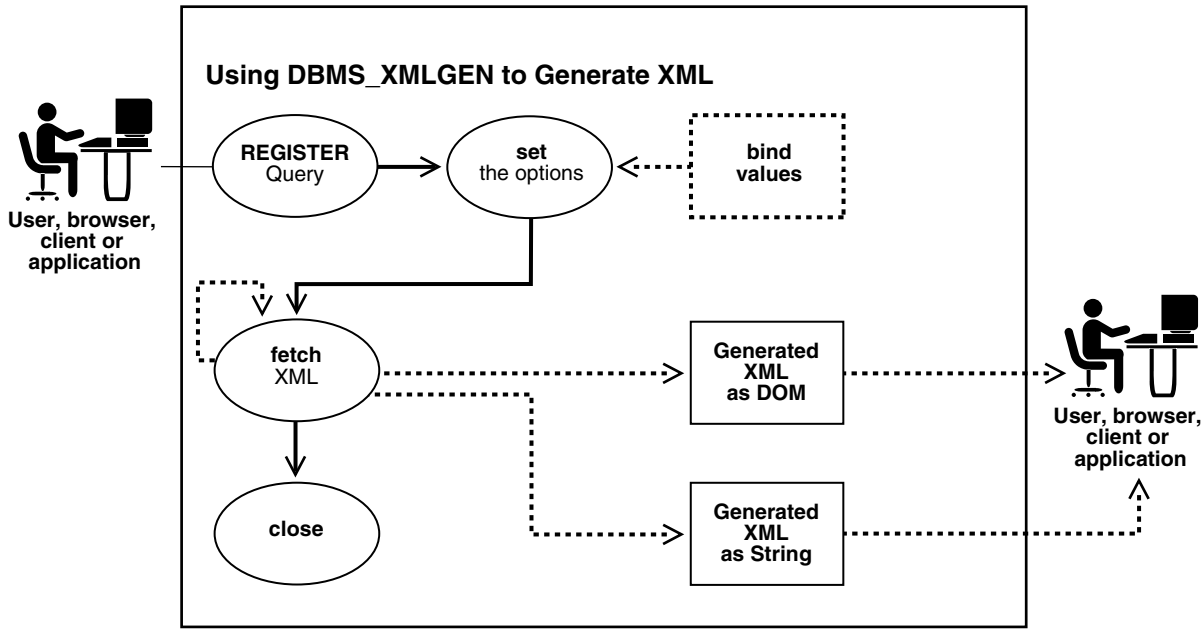
- *Oracle Database PL/SQL Packages and Types Reference*
- *Oracle XML Developer's Kit Programmer's Guide* (compare OracleXMLQuery with DBMS_XMLGEN)

Using PL/SQL Package DBMS_XMLGEN

Figure 8–13 illustrates how to use package DBMS_XMLGEN. The steps are as follows:

1. Get the context from the package by supplying a SQL query and calling PL/SQL function newContext.
2. Pass the context to all procedures or functions in the package to set the various options. For example, to set the ROW element name, use setRowTag(ctx), where ctx is the context got from the previous newContext call.
3. Get the XML result, using PL/SQL function getXML or getXMLType. By setting the maximum number of rows to be retrieved for each fetch using PL/SQL procedure setMaxRows, you can call either of these functions repeatedly, retrieving up to the maximum number of rows for each call. These functions return XML data (as a CLOB value and as an instance of XMLType, respectively), unless there are no rows retrieved. In that case, these functions return NULL. To determine how many rows were retrieved, use PL/SQL function getNumRowsProcessed.
4. You can reset the query to start again and repeat step 3.
5. Call PL/SQL procedure closeContext to free up any previously allocated resources.

Figure 8–13 Using PL/SQL Package DBMS_XMLGEN



In conjunction with a SQL query, PL/SQL method `DBMS_XMLGEN.getXML()` typically returns a result similar to the following, as a `CLOB` value:

```
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>100</EMPLOYEE_ID>
  <FIRST_NAME>Steven</FIRST_NAME>
  <LAST_NAME>King</LAST_NAME>
  <EMAIL>SKING</EMAIL>
  <PHONE_NUMBER>515.123.4567</PHONE_NUMBER>
  <HIRE_DATE>17-JUN-87</HIRE_DATE>
  <JOB_ID>AD_PRES</JOB_ID>
  <SALARY>24000</SALARY>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>101</EMPLOYEE_ID>
  <FIRST_NAME>Neena</FIRST_NAME>
  <LAST_NAME>Kochhar</LAST_NAME>
  <EMAIL>NKOCHHAR</EMAIL>
  <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
  <HIRE_DATE>21-SEP-89</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
</ROWSET>
```

The default mapping between relational data and XML data is as follows:

- Each row returned by the SQL query maps to an XML element with the default element name `ROW`.
- Each column returned by the SQL query maps to a child element of the `ROW` element.
- The entire result is wrapped in a `ROWSET` element.
- Binary data is transformed to its hexadecimal representation.

Element names `ROW` and `ROWSET` can be replaced with names you choose, using `DBMS_XMLGEN` procedures `setRowTagName` and `setRowSetTagName`, respectively.

The `CLOB` value returned by `getXML` has the same encoding as the database character set. If the database character set is SHIFTJIS, then the XML document returned is also SHIFTJIS.

Functions and Procedures of Package DBMS_XMLGEN

Table 8–1 describes the functions and procedures of package `DBMS_XMLGEN`.

Table 8–1 DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description

`SUBTYPE ctxHandle IS NUMBER`	The context handle used by all functions.
	Document Type Definition (DTD) or schema specifications:
	`NONE CONSTANT NUMBER:= 0;`
	`DTD CONSTANT NUMBER:= 1;`
	`SCHEMA CONSTANT NUMBER:= 2;`
	Can be used in function `getXML` to specify whether to generate a DTD or XML schema or neither (`NONE`). Only the `NONE` specification is supported.

`newContext()`	Given a query string, generate a new context handle to be used in subsequent functions.
`newContext(` `  queryString IN VARCHAR2)`	Returns a new context *Parameter:* `queryString (IN)`- the query string, the result of which must be converted to XML *Returns:* Context handle. Call this function first to obtain a handle that you can use in the `getXML` and other functions to get the XML back from the result.

`newContext(`
`  queryString IN SYS_REFCURSOR)`
`  RETURN ctxHandle;`
	Creates a new context handle from a PL/SQL cursor variable. The context handle can be used for the rest of the functions.

`newContextFromHierarchy(`
`  queryString IN VARCHAR2)`
`  RETURN ctxHandle;`
	Parameter: `queryString (IN)` - the query string, the result of which must be converted to XML. The query is a hierarchical query typically formed using a `CONNECT BY` clause, and the result must have the same property as the result set generated by a `CONNECT BY` query. The result set must have only two columns, the level number and an XML value. The level number is used to determine the hierarchical position of the XML value within the result XML document.
	Returns: Context handle. Call this function first to obtain a handle that you can use in the `getXML` and other functions to get a hierarchical XML with recursive elements back from the result.

`setRowTag()`	Sets the name of the element separating all the rows. The default name is `ROW`.
`setRowTag(ctx IN ctxHandle,` `  rowTag IN VARCHAR2);`	*Parameters:* `ctx(IN)` - the context handle obtained from the `newContext` call. `rowTag(IN)` - the name of the `ROW` element. A `NULL` value for `rowTag` indicates that you do not want the `ROW` element to be present. Call this procedure to set the name of the `ROW` element, if you do not want the default `ROW` name to show up. You can also set `rowTag` to `NULL` to suppress the `ROW` element itself. However, since getXML returns complete XML documents, not XML fragments, there must be a (single) root element. Therefore, an error is raised if both the `rowTag` value and the `rowSetTag` value (see `setRowSetTag`, next) are `NULL` and there is more than one column or row in the output.
`setRowSetTag()`	Sets the name of the document root element. The default name is `ROWSET`

Table 8–1 (Cont.) DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description
`setRowSetTag(ctx IN ctxHandle, rowSetTag IN VARCHAR2);`	*Parameters:* `ctx(IN)` – the context handle obtained from the `newContext` call. `rowSetTag(IN)` – the name of the document root element to be used in the output. A `NULL` value for `rowSetTag` indicates that you do *not* want the `ROWSET` element to be present. Call this procedure to set the name of the document root element, if you do not want the default name `ROWSET` to be used. You can set `rowSetTag` to `NULL` to suppress printing of the document root element. However, since function `getXML` returns complete XML documents, not XML fragments, there must be a (single) root element. Therefore, an error is raised if both the `rowTag` value and the `rowSetTag` value (see `setRowTag`, previous) are `NULL` and there is more than one column or row in the output, or if the `rowSetTag` value is `NULL` and there is more than one row in the output.
`getXML()`	Gets the XML document by fetching the maximum number of rows specified. It appends the XML document to the `CLOB` passed in.
`getXML(ctx IN ctxHandle, clobval IN OUT NCOPY clob, dtdOrSchema IN number:= NONE);`	*Parameters:* `ctx(IN)` - The context handle obtained from calling `newContext`. `clobval(IN/OUT)` - the `CLOB` to which the XML document is to be appended, `dtdOrSchema(IN)` - whether you should generate the DTD or Schema. This parameter is NOT supported. Use this version of the getXML function, to avoid any extra `CLOB` copies and if you want to reuse the same `CLOB` for subsequent calls. This `getXML` call is more efficient than the next flavor, though this involves that you create the LOB locator. When generating the XML, the number of rows indicated by the `setSkipRows` call are skipped, then the maximum number of rows as specified by the `setMaxRows` call (or the entire result if not specified) is fetched and converted to XML. Use the `getNumRowsProcessed` function to check if any rows were retrieved or not.
`getXML()`	Generates the XML document and returns it as a `CLOB`.
`getXML(ctx IN ctxHandle, dtdOrSchema IN number:= NONE) RETURN clob;`	*Parameters:* `ctx(IN)` - The context handle obtained from calling `newContext`. `dtdOrSchema(IN)` - whether to generate a DTD or XML schema. This parameter is *not* supported. *Returns:* A temporary `CLOB` containing the document. Free the temporary `CLOB` obtained from this function using the `DBMS_LOB.freeTemporary` call.
`getXMLType( ctx IN ctxHandle, dtdOrSchema IN number:= NONE) RETURN XMLType;`	*Parameters:* `ctx(IN)` - The context handle obtained from calling `newContext`. `dtdOrSchema(IN)` - whether to generate a DTD or XML schema. This parameter is *not* supported. *Returns:* An `XMLType` instance containing the document.

Table 8–1 (Cont.) DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description
`getXML( sqlQuery IN VARCHAR2, dtdOrSchema IN NUMBER := NONE) RETURN CLOB;`	Converts the query results from the SQL query string `sqlQuery` to XML format. *Returns:* A `CLOB` instance.
`getXMLType( sqlQuery IN VARCHAR2, dtdOrSchema IN NUMBER := NONE) RETURN XMLType;`	Converts the query results from the SQL query string `sqlQuery` to XML format. *Returns:* An `XMLType` instance.
`getNumRowsProcessed()`	Gets the number of SQL rows processed when generating XML data using function `getXML`. This count does not include the number of rows *skipped* before generating XML data.
`getNumRowsProcessed(ctx IN ctxHandle) RETURN number;`	*Parameter:* `queryString(IN)`- the query string, the result of which must be converted to XML *Returns:* The number of SQL rows that were processed in the last call to `getXML`. You can call this to find out if the end of the result set has been reached. This does not include the number of rows *skipped* before generating XML data. Use this function to determine the terminating condition if you are calling `getXML` in a loop. Note that `getXML` would always generate an XML document even if there are no rows present.
`setMaxRows()`	Sets the maximum number of rows to fetch from the SQL query result for every invocation of the `getXML` call. It is an error to call this function on a context handle created by function `newContextFromHierarchy`.
`setMaxRows(ctx IN ctxHandle, maxRows IN NUMBER);`	*Parameters:* `ctx(IN)` - the context handle corresponding to the query executed, `maxRows(IN)` - the maximum number of rows to get for each call to `getXML`. The `maxRows` parameter can be used when generating paginated results using this utility. For instance when generating a page of XML or HTML data, you can restrict the number of rows converted to XML and then in subsequent calls, you can get the next set of rows and so on. This also can provide for faster response times. It is an error to call this procedure on a context handle created by function `newContextFromHierarchy`.
`setSkipRows()`	Skips a given number of rows before generating the XML output for every call to `getXML`. It is an error to call this function on a context handle created by function `newContextFromHierarchy`.
`setSkipRows(ctx IN ctxHandle, skipRows IN NUMBER);`	*Parameters:* `ctx(IN)` - the context handle corresponding to the query executed, `skipRows(IN)` - the number of rows to skip for each call to `getXML`. The `skipRows` parameter can be used when generating paginated results for stateless Web pages using this utility. For instance when generating the first page of XML or HTML data, you can set `skipRows` to zero. For the next set, you can set the `skipRows` to the number of rows that you got in the first case. It is an error to call this function on a context handle created by function `newContextFromHierarchy`.

Table 8–1 (Cont.) DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description
`setConvertSpecialChars()`	Determines whether or not special characters in the XML data must be converted into their escaped XML equivalent. For example, the < sign is converted to `<`. The default behavior is to perform escape conversions.
`setConvertSpecialChars( ctx IN ctxHandle, conv IN BOOLEAN);`	*Parameters:* `ctx(IN)` - the context handle to use, `conv(IN)` - true indicates that conversion is needed. You can use this function to speed up the XML processing whenever you are sure that the input data cannot contain any special characters such as **<**, **>**, **"**, **'**, and so on, which must be preceded by an escape character. It is expensive to scan the character data to replace the special characters, particularly if it involves a lot of data. So, in cases when the data is XML-safe, this function can be called to improve performance.
`useItemTagsForColl()`	Sets the name of the collection elements. The default name for collection elements is the type name itself. You can override that to use the name of the column with the `_ITEM` tag appended to it using this function.
`useItemTagsForColl(ctx IN ctxHandle);`	*Parameter:* `ctx(IN)` - the context handle. If you have a collection of `NUMBER`, say, the default tag name for the collection elements is `NUMBER`. You can override this action and generate the collection column name with the `_ITEM` tag appended to it, by calling this procedure.
`restartQuery()`	Restarts the query and generate the XML from the first row again.
`restartQuery(ctx IN ctxHandle);`	*Parameter:* `ctx(IN)` - the context handle corresponding to the current query. You can call this to start executing the query again, without having to create a new context.
`closeContext()`	Closes a given context and releases all resources associated with that context, including the SQL cursor and bind and define buffers, and so on.
`closeContext(ctx IN ctxHandle);`	*Parameter:* `ctx(IN)` - the context handle to close. Closes all resources associated with this handle. After this you cannot use the handle for any other `DBMS_XMLGEN` function call.
Conversion Functions	
`convert( xmlData IN varchar2, flag IN NUMBER := ENTITY_ENCODE) RETURN VARCHAR2;`	Encodes or decodes the XML data string argument. ■ Encoding refers to replacing entity references such as < to their escaped equivalent, such as `<`. ■ Decoding refers to the reverse conversion.
`convert( xmlData IN CLOB, flag IN NUMBER := ENTITY_ENCODE) RETURN CLOB;`	Encodes or decodes the passed in XML `CLOB` data. ■ Encoding refers to replacing entity references such as < to their escaped equivalent, such as `<`. ■ Decoding refers to the reverse conversion.

Table 8–1 (Cont.) DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description
NULL Handling `setNullHandling(ctx IN ctxHandle, flag IN NUMBER);`	The `setNullHandling` flag values are: ■ `DROP_NULLS CONSTANT NUMBER := 0;` This is the default setting and leaves out the tag for `NULL` elements. ■ `NULL_ATTR CONSTANT NUMBER := 1;` This sets `xsi:nil = "true"`. ■ `EMPTY_TAG CONSTANT NUMBER := 2;` This sets, for example, `<foo/>`.
`useNullAttributeIndicator( ctx IN ctxHandle, attrind IN BOOLEAN := TRUE);`	`useNullAttributeIndicator` is a shortcut for `setNullHandling(ctx, NULL_ATTR)`.
`setBindValue( ctx IN ctxHandle, bindVariableName IN VARCHAR2, bindValue IN VARCHAR2);`	Sets bind value for the bind variable appearing in the query string associated with the context handle. The query string with bind variables cannot be executed until all of the bind variables are set values using `setBindValue`.
`clearBindValue(ctx IN ctxHandle);`	Clears all the bind values for all the bind variables appearing in the query string associated with the context handle. Afterwards, all of the bind variables must rebind new values using `setBindValue`.

DBMS_XMLGEN Examples

Example 8–22 uses `DBMS_XMLGEN` to create an XML document by selecting employee data from an object-relational table and putting the resulting `CLOB` value into a table.

Example 8–22 DBMS_XMLGEN: Generating Simple XML

```
CREATE TABLE temp_clob_tab (result CLOB);

DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  result CLOB;
BEGIN
  qryCtx := DBMS_XMLGEN.newContext(
              'SELECT * FROM hr.employees WHERE employee_id = 101');
  -- Set the row header to be EMPLOYEE
  DBMS_XMLGEN.setRowTag(qryCtx, 'EMPLOYEE');
  -- Get the result
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES(result);
  --Close context
  DBMS_XMLGEN.closeContext(qryCtx);
END;
/
```

That generates the following XML document:

```
SELECT * FROM temp_clob_tab;

RESULT
------------------------------------------------------
<?xml version="1.0"?>
<ROWSET>
 <EMPLOYEE>
```

```
  <EMPLOYEE_ID>101</EMPLOYEE_ID>
  <FIRST_NAME>Neena</FIRST_NAME>
  <LAST_NAME>Kochhar</LAST_NAME>
  <EMAIL>NKOCHHAR</EMAIL>
  <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
  <HIRE_DATE>21-SEP-05</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </EMPLOYEE>
</ROWSET>

1 row selected.
```

Instead of generating all of the XML data for all rows, you can use the fetch interface of package `DBMS_XMLGEN` to retrieve a fixed number of rows each time. This speeds up response time and can help in scaling applications that need a Document Object Model (DOM) Application Program Interface (API) on the resulting XML, particularly if the number of rows is large.

Example 8–23 uses `DBMS_XMLGEN` to retrieve results from table `HR.employees`:

Example 8–23 DBMS_XMLGEN: Generating Simple XML with Pagination (Fetch)

```
-- Create a table to hold the results
CREATE TABLE temp_clob_tab (result clob);
DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  result CLOB;
BEGIN
  -- Get the query context;
  qryCtx := DBMS_XMLGEN.newContext('SELECT * FROM hr.employees');
  -- Set the maximum number of rows to be 2
  DBMS_XMLGEN.setMaxRows(qryCtx, 2);
  LOOP
    -- Get the result
    result := DBMS_XMLGEN.getXML(qryCtx);
    -- If no rows were processed, then quit
    EXIT WHEN DBMS_XMLGEN.getNumRowsProcessed(qryCtx) = 0;

    -- Do some processing with the lob data
    --   Insert the results into a table.
    --   You can print the lob out, output it to a stream,
    --   put it in a queue, or do any other processing.
    INSERT INTO temp_clob_tab VALUES(result);
  END LOOP;
  --close context
  DBMS_XMLGEN.closeContext(qryCtx);
END;
/

SELECT * FROM temp_clob_tab WHERE rownum < 3;

RESULT
------------------------------------------------------------
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>100</EMPLOYEE_ID>
```

```
  <FIRST_NAME>Steven</FIRST_NAME>
  <LAST_NAME>King</LAST_NAME>
  <EMAIL>SKING</EMAIL>
  <PHONE_NUMBER>515.123.4567</PHONE_NUMBER>
  <HIRE_DATE>17-JUN-03</HIRE_DATE>
  <JOB_ID>AD_PRES</JOB_ID>
  <SALARY>24000</SALARY>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>101</EMPLOYEE_ID>
  <FIRST_NAME>Neena</FIRST_NAME>
  <LAST_NAME>Kochhar</LAST_NAME>
  <EMAIL>NKOCHHAR</EMAIL>
  <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
  <HIRE_DATE>21-SEP-05</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
</ROWSET>

<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>102</EMPLOYEE_ID>
  <FIRST_NAME>Lex</FIRST_NAME>
  <LAST_NAME>De Haan</LAST_NAME>
  <EMAIL>LDEHAAN</EMAIL>
  <PHONE_NUMBER>515.123.4569</PHONE_NUMBER>
  <HIRE_DATE>13-JAN-01</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>103</EMPLOYEE_ID>
  <FIRST_NAME>Alexander</FIRST_NAME>
  <LAST_NAME>Hunold</LAST_NAME>
  <EMAIL>AHUNOLD</EMAIL>
  <PHONE_NUMBER>590.423.4567</PHONE_NUMBER>
  <HIRE_DATE>03-JAN-06</HIRE_DATE>
  <JOB_ID>IT_PROG</JOB_ID>
  <SALARY>9000</SALARY>
  <MANAGER_ID>102</MANAGER_ID>
  <DEPARTMENT_ID>60</DEPARTMENT_ID>
 </ROW>
</ROWSET>

2 rows selected.
```

Example 8–24 uses DBMS_XMLGEN with object types to represent nested structures.

Example 8–24 DBMS_XMLGEN: Generating XML Using Object Types

```
CREATE TABLE new_departments (department_id   NUMBER PRIMARY KEY,
                              department_name VARCHAR2(20));
CREATE TABLE new_employees (employee_id       NUMBER PRIMARY KEY,
```

```
                            last_name         VARCHAR2(20),
                            department_id     NUMBER REFERENCES new_departments);
CREATE TYPE emp_t AS OBJECT ("@employee_id"   NUMBER,
                             last_name        VARCHAR2(20));
/
INSERT INTO new_departments VALUES (10, 'SALES');
INSERT INTO new_departments VALUES (20, 'ACCOUNTING');
INSERT INTO new_employees   VALUES (30, 'Scott', 10);
INSERT INTO new_employees   VALUES (31, 'Mary',  10);
INSERT INTO new_employees   VALUES (40, 'John',  20);
INSERT INTO new_employees   VALUES (41, 'Jerry', 20);
COMMIT;
CREATE TYPE emplist_t AS TABLE OF emp_t;
/
CREATE TYPE dept_t AS OBJECT ("@department_id" NUMBER,
                              department_name  VARCHAR2(20),
                              emplist          emplist_t);
/
CREATE TABLE temp_clob_tab (result CLOB);
DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  result CLOB;
BEGIN
  DBMS_XMLGEN.setRowTag(qryCtx, NULL);
  qryCtx := DBMS_XMLGEN.newContext
    ('SELECT dept_t(department_id,
                    department_name,
                    cast(MULTISET
                         (SELECT e.employee_id, e.last_name
                            FROM new_employees e
                            WHERE e.department_id = d.department_id)
                         AS emplist_t))
        AS deptxml
        FROM new_departments d');
  -- now get the result
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES (result);
  -- close context
  DBMS_XMLGEN.closeContext(qryCtx);
END;
/
SELECT * FROM temp_clob_tab;
```

Here is the resulting XML:

```
RESULT
-----------------------------------------
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <DEPTXML department_id="10">
   <DEPARTMENT_NAME>SALES</DEPARTMENT_NAME>
   <EMPLIST>
    <EMP_T employee_id="30">
     <LAST_NAME>Scott</LAST_NAME>
    </EMP_T>
    <EMP_T employee_id="31">
     <LAST_NAME>Mary</LAST_NAME>
    </EMP_T>
   </EMPLIST>
  </DEPTXML>
```

```
 </ROW>
 <ROW>
  <DEPTXML department_id="20">
   <DEPARTMENT_NAME>ACCOUNTING</DEPARTMENT_NAME>
   <EMPLIST>
    <EMP_T employee_id="40">
     <LAST_NAME>John</LAST_NAME>
    </EMP_T>
    <EMP_T employee_id="41">
     <LAST_NAME>Jerry</LAST_NAME>
    </EMP_T>
   </EMPLIST>
  </DEPTXML>
 </ROW>
</ROWSET>

1 row selected.
```

With relational data, the result is an XML document without nested elements. To obtain nested XML structures, you can use object-relational data, where the mapping is as follows:

- *Object types* map to XML elements – see Chapter 17, "XML Schema Storage and Query: Basic".
- *Attributes of the type* map to sub-elements of the parent element

> **Note:** Complex structures can be obtained by using object types and creating object views or object tables. A canonical mapping is used to map object instances to XML.
>
> When used in column names or attribute names, the at-sign (`@`) is translated into an attribute of the enclosing XML element in the mapping.

When you provide a user-defined data-type instance to `DBMS_XMLGEN` functions, the user-defined data-type instance is mapped to an XML document using a canonical mapping: the *attributes* of the user-defined data type are mapped to XML *elements*. Attributes with names starting with an at-sign character (`@`) are mapped to attributes of the preceding element.

User-defined data-type instances can be used for nesting in the resulting XML document.

For example, consider the tables `emp` and `dept` defined in Example 8–25. To generate a hierarchical view of the data, that is, departments with their employees, Example 8–25 defines suitable object types to create the structure inside the database.

Example 8–25 DBMS_XMLGEN: Generating XML Using User-Defined Data-Type Instances

```
CREATE TABLE dept (deptno NUMBER PRIMARY KEY, dname VARCHAR2(20));
CREATE TABLE emp (empno   NUMBER PRIMARY KEY, ename VARCHAR2(20),
                  deptno  NUMBER REFERENCES dept);

-- empno is preceded by an at-sign (@) to indicate that it must
-- be mapped as an attribute of the enclosing Employee element.
CREATE TYPE emp_t AS OBJECT ("@empno" NUMBER,  -- empno defined as attribute
                             ename   VARCHAR2(20));
```

```
/
INSERT INTO DEPT VALUES (10, 'Sports');
INSERT INTO DEPT VALUES(20, 'Accounting');
INSERT INTO EMP VALUES(200, 'John',  10);
INSERT INTO EMP VALUES(300, 'Jack',  10);
INSERT INTO EMP VALUES(400, 'Mary',  20);
INSERT INTO EMP VALUES(500, 'Jerry', 20);
COMMIT;
CREATE TYPE emplist_t AS TABLE OF emp_t;
/
CREATE TYPE dept_t AS OBJECT("@deptno" NUMBER,
                             dname     VARCHAR2(20),
                             emplist   emplist_t);
/
-- Department type dept_t contains a list of employees.
-- You can now query the employee and department tables and get
-- the result as an XML document, as follows:
CREATE TABLE temp_clob_tab (result CLOB);
DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  RESULT CLOB;
BEGIN
  -- get query context
  qryCtx := DBMS_XMLGEN.newContext(
    'SELECT dept_t(deptno,
                   dname,
                   cast(MULTISET
                        (SELECT empno, ename FROM emp e WHERE e.deptno = d.deptno)
                        AS emplist_t))
       AS deptxml
       FROM dept d');
  -- set maximum number of rows to 5
  DBMS_XMLGEN.setMaxRows(qryCtx, 5);
  -- set no row tag for this result, since there is a single ADT column
  DBMS_XMLGEN.setRowTag(qryCtx, NULL);
  LOOP
    -- get result
    result := DBMS_XMLGEN.getXML(qryCtx);
    -- if there were no rows processed, then quit
    EXIT WHEN DBMS_XMLGEN.getNumRowsProcessed(qryCtx) = 0;
    -- do something with the result
    INSERT INTO temp_clob_tab VALUES (result);
  END LOOP;
END;
/
```

The `MULTISET` keyword for Oracle SQL function `cast` treats the employees working in the department as a list, which `cast` assigns to the appropriate collection type. A department instance is created using constructor `dept_t`, and `DBMS_XMLGEN` routines create the XML data for the object instance.

```
SELECT * FROM temp_clob_tab;

RESULT
--------------------------------
<?xml version="1.0"?>
<ROWSET>
 <DEPTXML deptno="10">
  <DNAME>Sports</DNAME>
  <EMPLIST>
```

```
   <EMP_T empno="200">
    <ENAME>John</ENAME>
   </EMP_T>
   <EMP_T empno="300">
    <ENAME>Jack</ENAME>
   </EMP_T>
  </EMPLIST>
 </DEPTXML>
 <DEPTXML deptno="20">
  <DNAME>Accounting</DNAME>
  <EMPLIST>
   <EMP_T empno="400">
    <ENAME>Mary</ENAME>
   </EMP_T>
   <EMP_T empno="500">
    <ENAME>Jerry</ENAME>
   </EMP_T>
  </EMPLIST>
 </DEPTXML>
</ROWSET>

1 row selected.
```

The default name `ROW` is not present because it was set to `NULL`. The `deptno` and `empno` have become attributes of the enclosing element.

Example 8–26 uses `DBMS_XMLGEN.getXMLType` to generate a purchase order document in XML format using object views.

Example 8–26 DBMS_XMLGEN: Generating an XML Purchase Order

```
-- Create relational schema and define object views
-- DBMS_XMLGEN maps user-defined data-type attribute names that start
--    with an at-sign (@) to XML attributes

-- Purchase Order Object View Model

-- PhoneList varray object type
CREATE TYPE phonelist_vartyp AS VARRAY(10) OF VARCHAR2(20)
/
-- Address object type
CREATE TYPE address_typ AS OBJECT(Street VARCHAR2(200),
                                  City   VARCHAR2(200),
                                  State  CHAR(2),
                                  Zip    VARCHAR2(20))
/
-- Customer object type
CREATE TYPE customer_typ AS OBJECT(CustNo    NUMBER,
                                   CustName  VARCHAR2(200),
                                   Address   address_typ,
                                   PhoneList phonelist_vartyp)
/
-- StockItem object type
CREATE TYPE stockitem_typ AS OBJECT("@StockNo" NUMBER,
                                    Price      NUMBER,
                                    TaxRate    NUMBER)
/
-- LineItems object type
CREATE TYPE lineitem_typ AS OBJECT("@LineItemNo" NUMBER,
                                   Item          stockitem_typ,
                                   Quantity      NUMBER,
```

```
                                  Discount      NUMBER)
/
-- LineItems ordered collection table
CREATE TYPE lineitems_ntabtyp AS TABLE OF lineitem_typ
/
-- Purchase Order object type
CREATE TYPE po_typ AUTHID CURRENT_USER
  AS OBJECT(PONO            NUMBER,
            Cust_ref        REF customer_typ,
            OrderDate       DATE,
            ShipDate        TIMESTAMP,
            LineItems_ntab  lineitems_ntabtyp,
            ShipToAddr      address_typ)
/
-- Create Purchase Order relational model tables
-- Customer table
CREATE TABLE customer_tab (CustNo     NUMBER NOT NULL,
                           CustName   VARCHAR2(200),
                           Street     VARCHAR2(200),
                           City       VARCHAR2(200),
                           State      CHAR(2),
                           Zip        VARCHAR2(20),
                           Phone1     VARCHAR2(20),
                           Phone2     VARCHAR2(20),
                           Phone3     VARCHAR2(20),
                           CONSTRAINT cust_pk PRIMARY KEY (CustNo));
-- Purchase Order table
CREATE TABLE po_tab (PONo       NUMBER,        /* purchase order number */
                     Custno     NUMBER     /*  foreign KEY referencing customer */
                                CONSTRAINT po_cust_fk REFERENCES customer_tab,
                     OrderDate  DATE,          /*  date of order */
                     ShipDate   TIMESTAMP,     /* date to be shipped */
                     ToStreet   VARCHAR2(200), /* shipto address */
                     ToCity     VARCHAR2(200),
                     ToState    CHAR(2),
                     ToZip      VARCHAR2(20),
                     CONSTRAINT po_pk PRIMARY KEY(PONo));
--Stock Table
CREATE TABLE stock_tab (StockNo NUMBER CONSTRAINT stock_uk UNIQUE,
                        Price   NUMBER,
                        TaxRate NUMBER);
--Line Items table
CREATE TABLE lineitems_tab (LineItemNo NUMBER,
                            PONo       NUMBER
                                       CONSTRAINT li_po_fk REFERENCES po_tab,
                            StockNo    NUMBER,
                            Quantity   NUMBER,
                            Discount   NUMBER,
                            CONSTRAINT li_pk PRIMARY KEY (PONo, LineItemNo));
-- Create Object views
-- Customer Object View
CREATE OR REPLACE VIEW customer OF customer_typ
  WITH OBJECT IDENTIFIER(CustNo)
  AS SELECT c.custno, c.custname,
            address_typ(c.street, c.city, c.state, c.zip),
            phonelist_vartyp(phone1, phone2, phone3)
       FROM customer_tab c;
--Purchase order view
CREATE OR REPLACE VIEW po OF po_typ
  WITH OBJECT IDENTIFIER (PONo)
```

```
  AS SELECT p.pono, make_ref(Customer, P.Custno), p.orderdate, p.shipdate,
            cast(MULTISET
                 (SELECT lineitem_typ(l.lineitemno,
                                      stockitem_typ(l.stockno, s.price,
                                                    s.taxrate),
                                      l.quantity, l.discount)
                    FROM lineitems_tab l, stock_tab s
                    WHERE l.pono = p.pono AND s.stockno=l.stockno)
                 AS lineitems_ntabtyp),
            address_typ(p.tostreet,p.tocity, p.tostate, p.tozip)
       FROM po_tab p;
-- Create table with XMLType column to store purchase order in XML format
CREATE TABLE po_xml_tab (poid  NUMBER, podoc XMLType)
/
-- Populate data
-------------------
-- Establish Inventory
INSERT INTO stock_tab VALUES(1004, 6750.00, 2);
INSERT INTO stock_tab VALUES(1011, 4500.23, 2);
INSERT INTO stock_tab VALUES(1534, 2234.00, 2);
INSERT INTO stock_tab VALUES(1535, 3456.23, 2);
-- Register Customers
INSERT INTO customer_tab
  VALUES (1, 'Jean Nance', '2 Avocet Drive',
          'Redwood Shores', 'CA', '95054',
          '415-555-1212', NULL, NULL);
INSERT INTO customer_tab
  VALUES (2, 'John Nike', '323 College Drive',
          'Edison', 'NJ', '08820',
          '609-555-1212', '201-555-1212', NULL);
-- Place orders
INSERT INTO po_tab
  VALUES (1001, 1, '10-APR-1997', '10-MAY-1997',
          NULL, NULL, NULL, NULL);
INSERT INTO po_tab
  VALUES (2001, 2, '20-APR-1997', '20-MAY-1997',
          '55 Madison Ave', 'Madison', 'WI', '53715');
-- Detail line items
INSERT INTO lineitems_tab VALUES(01, 1001, 1534, 12,  0);
INSERT INTO lineitems_tab VALUES(02, 1001, 1535, 10, 10);
INSERT INTO lineitems_tab VALUES(01, 2001, 1004,  1,  0);
INSERT INTO lineitems_tab VALUES(02, 2001, 1011,  2,  1);

-- Use package DBMS_XMLGEN to generate purchase order in XML format
--   and store XMLType in table po_xml
DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  pxml XMLType;
  cxml CLOB;
BEGIN
  -- get query context;
  qryCtx := DBMS_XMLGEN.newContext('SELECT pono,deref(cust_ref) customer,
                                          p.orderdate,
                                          p.shipdate,
                                          lineitems_ntab lineitems,
                                          shiptoaddr
                                     FROM po p');
  -- set maximum number of rows to be 1,
  DBMS_XMLGEN.setMaxRows(qryCtx, 1);
  -- set ROWSET tag to NULL and ROW tag to PurchaseOrder
```

```
  DBMS_XMLGEN.setRowSetTag(qryCtx, NULL);
  DBMS_XMLGEN.setRowTag(qryCtx, 'PurchaseOrder');
  LOOP
    -- get purchase order in XML format
    pxml := DBMS_XMLGEN.getXMLType(qryCtx);
    -- if there were no rows processed, then quit
    EXIT WHEN DBMS_XMLGEN.getNumRowsProcessed(qryCtx) = 0;
    -- Store XMLType po in po_xml table (get the pono out)
    INSERT INTO po_xml_tab(poid, poDoc)
      VALUES(XMLCast(XMLQuery('//PONO/text()' PASSING pxml RETURNING CONTENT)
                     AS NUMBER),
             pxml);
  END LOOP;
END;
/
```

This query then produces two XML purchase-order documents:

```
SELECT XMLSerialize(DOCUMENT x.podoc AS CLOB) xpo FROM po_xml_tab x;

XPO
----------------------------------------------------
 <PurchaseOrder>
  <PONO>1001</PONO>
  <CUSTOMER>
   <CUSTNO>1</CUSTNO>
   <CUSTNAME>Jean Nance</CUSTNAME>
   <ADDRESS>
    <STREET>2 Avocet Drive</STREET>
    <CITY>Redwood Shores</CITY>
    <STATE>CA</STATE>
    <ZIP>95054</ZIP>
   </ADDRESS>
   <PHONELIST>
    <VARCHAR2>415-555-1212</VARCHAR2>
   </PHONELIST>
  </CUSTOMER>
  <ORDERDATE>10-APR-97</ORDERDATE>
  <SHIPDATE>10-MAY-97 12.00.00.000000 AM</SHIPDATE>
  <LINEITEMS>
   <LINEITEM_TYP LineItemNo="1">
    <ITEM StockNo="1534">
     <PRICE>2234</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>12</QUANTITY>
    <DISCOUNT>0</DISCOUNT>
   </LINEITEM_TYP>
   <LINEITEM_TYP LineItemNo="2">
    <ITEM StockNo="1535">
     <PRICE>3456.23</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>10</QUANTITY>
    <DISCOUNT>10</DISCOUNT>
   </LINEITEM_TYP>
  </LINEITEMS>
  <SHIPTOADDR/>
 </PurchaseOrder>

 <PurchaseOrder>
```

```
  <PONO>2001</PONO>
  <CUSTOMER>
   <CUSTNO>2</CUSTNO>
   <CUSTNAME>John Nike</CUSTNAME>
   <ADDRESS>
    <STREET>323 College Drive</STREET>
    <CITY>Edison</CITY>
    <STATE>NJ</STATE>
    <ZIP>08820</ZIP>
   </ADDRESS>
   <PHONELIST>
    <VARCHAR2>609-555-1212</VARCHAR2>
    <VARCHAR2>201-555-1212</VARCHAR2>
   </PHONELIST>
  </CUSTOMER>
  <ORDERDATE>20-APR-97</ORDERDATE>
  <SHIPDATE>20-MAY-97 12.00.00.000000 AM</SHIPDATE>
  <LINEITEMS>
   <LINEITEM_TYP LineItemNo="1">
    <ITEM StockNo="1004">
     <PRICE>6750</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>1</QUANTITY>
    <DISCOUNT>0</DISCOUNT>
   </LINEITEM_TYP>
   <LINEITEM_TYP LineItemNo="2">
    <ITEM StockNo="1011">
     <PRICE>4500.23</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>2</QUANTITY>
    <DISCOUNT>1</DISCOUNT>
   </LINEITEM_TYP>
  </LINEITEMS>
  <SHIPTOADDR>
   <STREET>55 Madison Ave</STREET>
   <CITY>Madison</CITY>
   <STATE>WI</STATE>
   <ZIP>53715</ZIP>
  </SHIPTOADDR>
 </PurchaseOrder>

2 rows selected.
```

Example 8–27 shows how to open a cursor variable for a query and use that cursor variable to create a new context handle for DBMS_XMLGEN.

Example 8–27 DBMS_XMLGEN: Generating a New Context Handle from a REF Cursor

```
CREATE TABLE emp_tab (emp_id       NUMBER PRIMARY KEY,
                      name         VARCHAR2(20),
                      dept_id      NUMBER);
Table created.
INSERT INTO emp_tab VALUES (122, 'Scott',  301);
1 row created.
INSERT INTO emp_tab VALUES (123, 'Mary',   472);
1 row created.
INSERT INTO emp_tab VALUES (124, 'John',   93);
1 row created.
```

```
INSERT INTO emp_tab VALUES (125, 'Howard', 488);
1 row created.
INSERT INTO emp_tab VALUES (126, 'Sue',    16);
1 row created.
COMMIT;

DECLARE
  ctx     NUMBER;
  maxrow  NUMBER;
  xmldoc  CLOB;
  refcur  SYS_REFCURSOR;
BEGIN
  DBMS_LOB.createtemporary(xmldoc, TRUE);
  maxrow := 3;
  OPEN refcur FOR 'SELECT * FROM emp_tab WHERE ROWNUM <= :1' USING maxrow;
  ctx := DBMS_XMLGEN.newContext(refcur);
   -- xmldoc will have 3 rows
  DBMS_XMLGEN.getXML(ctx, xmldoc, DBMS_XMLGEN.NONE);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_LOB.freetemporary(xmldoc);
  CLOSE refcur;
  DBMS_XMLGEN.closeContext(ctx);
END;
/
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMP_ID>122</EMP_ID>
  <NAME>Scott</NAME>
  <DEPT_ID>301</DEPT_ID>
 </ROW>
 <ROW>
  <EMP_ID>123</EMP_ID>
  <NAME>Mary</NAME>
  <DEPT_ID>472</DEPT_ID>
 </ROW>
 <ROW>
  <EMP_ID>124</EMP_ID>
  <NAME>John</NAME>
  <DEPT_ID>93</DEPT_ID>
 </ROW>
</ROWSET>

PL/SQL procedure successfully completed.
```

> **See Also:** *Oracle Database PL/SQL Language Reference* for more information about cursor variables (`REF CURSOR`)

Example 8–28 shows how to specify `NULL` handling when using `DBMS_XMLGEN`.

Example 8–28 DBMS_XMLGEN: Specifying NULL Handling

```
CREATE TABLE emp_tab (emp_id       NUMBER PRIMARY KEY,
                      name         VARCHAR2(20),
                      dept_id      NUMBER);
Table created.
INSERT INTO emp_tab VALUES (30, 'Scott', NULL);
1 row created.
INSERT INTO emp_tab VALUES (31, 'Mary', NULL);
1 row created.
```

```
INSERT INTO emp_tab VALUES (40, 'John', NULL);
1 row created.
COMMIT;
CREATE TABLE temp_clob_tab (result CLOB);
Table created.

DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  result CLOB;
BEGIN
  qryCtx := DBMS_XMLGEN.newContext('SELECT * FROM emp_tab where name = :NAME');
  -- Set the row header to be EMPLOYEE
  DBMS_XMLGEN.setRowTag(qryCtx, 'EMPLOYEE');
  -- Drop nulls
  DBMS_XMLGEN.setBindValue(qryCtx, 'NAME', 'Scott');
  DBMS_XMLGEN.setNullHandling(qryCtx, DBMS_XMLGEN.DROP_NULLS);
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES(result);
  -- Null attribute
  DBMS_XMLGEN.setBindValue(qryCtx, 'NAME', 'Mary');
  DBMS_XMLGEN.setNullHandling(qryCtx, DBMS_XMLGEN.NULL_ATTR);
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES(result);
  -- Empty tag
  DBMS_XMLGEN.setBindValue(qryCtx, 'NAME', 'John');
  DBMS_XMLGEN.setNullHandling(qryCtx, DBMS_XMLGEN.EMPTY_TAG);
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES(result);
  --Close context
  DBMS_XMLGEN.closeContext(qryCtx);
END;
/

PL/SQL procedure successfully completed.

SELECT * FROM temp_clob_tab;

RESULT
-----------------------------------------
<?xml version="1.0"?>
<ROWSET>
 <EMPLOYEE>
  <EMP_ID>30</EMP_ID>
  <NAME>Scott</NAME>
 </EMPLOYEE>
</ROWSET>

<?xml version="1.0"?>
<ROWSET xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance">
 <EMPLOYEE>
  <EMP_ID>31</EMP_ID>
  <NAME>Mary</NAME>
  <DEPT_ID xsi:nil = "true"/>
 </EMPLOYEE>
</ROWSET>

<?xml version="1.0"?>
<ROWSET>
 <EMPLOYEE>
  <EMP_ID>40</EMP_ID>
```

```
  <NAME>John</NAME>
  <DEPT_ID/>
 </EMPLOYEE>
</ROWSET>

3 rows selected.
```

Function DBMS_XMLGEN.newContextFromHierarchy takes as argument a hierarchical query string, which is typically formulated with a CONNECT BY clause. It returns a context that can be used to generate a hierarchical XML document with recursive elements.

The hierarchical query returns two columns, the level number (a pseudocolumn generated by CONNECT BY query) and an XMLType instance. The level is used to determine the position of the XMLType value within the hierarchy of the result XML document.

It is an error to set the skip number of rows or the maximum number of rows for a context created using newContextFromHierarchy.

Example 8–29 uses DBMS_ XMLGEN.newContextFromHierarchy to generate a manager–employee hierarchy.

Example 8–29 DBMS_XMLGEN: Generating Recursive XML with a Hierarchical Query

```
CREATE TABLE sqlx_display (id NUMBER, xmldoc XMLType);
Table created.

DECLARE
  qryctx DBMS_XMLGEN.ctxhandle;
  result XMLType;
BEGIN
  qryctx :=
    DBMS_XMLGEN.newContextFromHierarchy(
      'SELECT level,
              XMLElement("employees",
                         XMLElement("enumber", employee_id),
                         XMLElement("name", last_name),
                         XMLElement("Salary", salary),
                         XMLElement("Hiredate", hire_date))
        FROM hr.employees
        START WITH last_name=''De Haan'' CONNECT BY PRIOR employee_id=manager_id
        ORDER SIBLINGS BY hire_date');
  result := DBMS_XMLGEN.getxmltype(qryctx);
  DBMS_OUTPUT.put_line('<result num rows>');
  DBMS_OUTPUT.put_line(to_char(DBMS_XMLGEN.getNumRowsProcessed(qryctx)));
  DBMS_OUTPUT.put_line('</result num rows>');
  INSERT INTO sqlx_display VALUES (2, result);
  COMMIT;
  DBMS_XMLGEN.closecontext(qryctx);
END;
/
<result num rows>
6
</result num rows>
PL/SQL procedure successfully completed.

SELECT xmldoc FROM sqlx_display WHERE id = 2;

XMLDOC
--------------------------------------------------
```

```
<?xml version="1.0"?>
<employees>
  <enumber>102</enumber>
  <name>De Haan</name>
  <Salary>17000</Salary>
  <Hiredate>2001-01-13</Hiredate>
  <employees>
    <enumber>103</enumber>
    <name>Hunold</name>
    <Salary>9000</Salary>
    <Hiredate>2006-01-03</Hiredate>
    <employees>
      <enumber>105</enumber>
      <name>Austin</name>
      <Salary>4800</Salary>
      <Hiredate>2005-06-25</Hiredate>
    </employees>
    <employees>
      <enumber>106</enumber>
      <name>Pataballa</name>
      <Salary>4800</Salary>
      <Hiredate>2006-02-05</Hiredate>
    </employees>
    <employees>
      <enumber>107</enumber>
      <name>Lorentz</name>
      <Salary>4200</Salary>
      <Hiredate>2007-02-07</Hiredate>
    </employees>
    <employees>
      <enumber>104</enumber>
      <name>Ernst</name>
      <Salary>6000</Salary>
      <Hiredate>2007-05-21</Hiredate>
    </employees>
  </employees>
</employees>

1 row selected.
```

By default, the `ROWSET` tag is `NULL`: there is no default `ROWSET` tag used to enclose the XML result. However, you can explicitly set the `ROWSET` tag by using procedure `setRowSetTag`, as follows:

```
CREATE TABLE gg (x XMLType);
Table created.

DECLARE
  qryctx DBMS_XMLGEN.ctxhandle;
  result CLOB;
BEGIN
  qryctx := DBMS_XMLGEN.newContextFromHierarchy(
              'SELECT level,
                      XMLElement("NAME", last_name) AS myname FROM hr.employees
               CONNECT BY PRIOR employee_id=manager_id
               START WITH employee_id = 102');
  DBMS_XMLGEN.setRowSetTag(qryctx, 'mynum_hierarchy');
  result:=DBMS_XMLGEN.getxml(qryctx);
  DBMS_OUTPUT.put_line('<result num rows>');
  DBMS_OUTPUT.put_line(to_char(DBMS_XMLGEN.getNumRowsProcessed(qryctx)));
```

```
  DBMS_OUTPUT.put_line('</result num rows>');
  INSERT INTO gg VALUES(XMLType(result));
  COMMIT;
  DBMS_XMLGEN.closecontext(qryctx);
END;
/
<result num rows>
6
</result num rows>
PL/SQL procedure successfully completed.

SELECT * FROM gg;

X
------------------------------------------------------------
<?xml version="1.0"?>
<mynum_hierarchy>
  <NAME>De Haan
    <NAME>Hunold
      <NAME>Ernst</NAME>
      <NAME>Austin</NAME>
      <NAME>Pataballa</NAME>
      <NAME>Lorentz</NAME>
    </NAME>
  </NAME>
</mynum_hierarchy>

1 row selected.
```

If the query string used to create a context contains host variables, you can use PL/SQL method `setBindValue()` to give the variables values before query execution. Example 8–30 illustrates this.

Example 8–30 DBMS_XMLGEN: Binding Query Variables Using SETBINDVALUE()

```
-- Bind one variable
DECLARE
  ctx NUMBER;
  xmldoc CLOB;
BEGIN
  ctx := DBMS_XMLGEN.newContext(
           'SELECT * FROM employees WHERE employee_id = :NO');
  DBMS_XMLGEN.setBindValue(ctx, 'NO', '145');
  xmldoc := DBMS_XMLGEN.getXML(ctx);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_XMLGEN.closeContext(ctx);
EXCEPTION
  WHEN OTHERS THEN DBMS_XMLGEN.closeContext(ctx);
  RAISE;
END;
/
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>145</EMPLOYEE_ID>
  <FIRST_NAME>John</FIRST_NAME>
  <LAST_NAME>Russell</LAST_NAME>
  <EMAIL>JRUSSEL</EMAIL>
  <PHONE_NUMBER>011.44.1344.429268</PHONE_NUMBER>
  <HIRE_DATE>01-OCT-04</HIRE_DATE>
```

```
  <JOB_ID>SA_MAN</JOB_ID>
  <SALARY>14000</SALARY>
  <COMMISSION_PCT>.4</COMMISSION_PCT>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
</ROWSET>

PL/SQL procedure successfully completed.

-- Bind one variable twice with different values
DECLARE
  ctx NUMBER;
  xmldoc CLOB;
BEGIN
  ctx := DBMS_XMLGEN.newContext('SELECT * FROM employees
                                   WHERE hire_date = :MDATE');
  DBMS_XMLGEN.setBindValue(ctx, 'MDATE', '01-OCT-04');
  xmldoc := DBMS_XMLGEN.getXML(ctx);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_XMLGEN.setBindValue(ctx, 'MDATE', '10-MAR-05');
  xmldoc := DBMS_XMLGEN.getXML(ctx);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_XMLGEN.closeContext(ctx);
EXCEPTION
  WHEN OTHERS THEN DBMS_XMLGEN.closeContext(ctx);
  RAISE;
END;
/
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>145</EMPLOYEE_ID>
  <FIRST_NAME>John</FIRST_NAME>
  <LAST_NAME>Russell</LAST_NAME>
  <EMAIL>JRUSSEL</EMAIL>
  <PHONE_NUMBER>011.44.1344.429268</PHONE_NUMBER>
  <HIRE_DATE>01-OCT-04</HIRE_DATE>
  <JOB_ID>SA_MAN</JOB_ID>
  <SALARY>14000</SALARY>
  <COMMISSION_PCT>.4</COMMISSION_PCT>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
</ROWSET>

<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>147</EMPLOYEE_ID>
  <FIRST_NAME>Alberto</FIRST_NAME>
  <LAST_NAME>Errazuriz</LAST_NAME>
  <EMAIL>AERRAZUR</EMAIL>
  <PHONE_NUMBER>011.44.1344.429278</PHONE_NUMBER>
  <HIRE_DATE>10-MAR-05</HIRE_DATE>
  <JOB_ID>SA_MAN</JOB_ID>
  <SALARY>12000</SALARY>
  <COMMISSION_PCT>.3</COMMISSION_PCT>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
```

```
 </ROW>
 <ROW>
  <EMPLOYEE_ID>159</EMPLOYEE_ID>
  <FIRST_NAME>Lindsey</FIRST_NAME>
  <LAST_NAME>Smith</LAST_NAME>
  <EMAIL>LSMITH</EMAIL>
  <PHONE_NUMBER>011.44.1345.729268</PHONE_NUMBER>
  <HIRE_DATE>10-MAR-97</HIRE_DATE>
  <JOB_ID>SA_REP</JOB_ID>
  <SALARY>8000</SALARY>
  <COMMISSION_PCT>.3</COMMISSION_PCT>
  <MANAGER_ID>146</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
</ROWSET>
PL/SQL procedure successfully completed.
-- Bind two variables
DECLARE
  ctx NUMBER;
  xmldoc CLOB;
BEGIN
  ctx := DBMS_XMLGEN.newContext('SELECT * FROM employees
                                   WHERE employee_id = :NO
                                     AND hire_date = :MDATE');
  DBMS_XMLGEN.setBindValue(ctx, 'NO', '145');
  DBMS_XMLGEN.setBindValue(ctx, 'MDATE', '01-OCT-04');
  xmldoc := DBMS_XMLGEN.getXML(ctx);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_XMLGEN.closeContext(ctx);
EXCEPTION
  WHEN OTHERS THEN DBMS_XMLGEN.closeContext(ctx);
  RAISE;
END;
/
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>145</EMPLOYEE_ID>
  <FIRST_NAME>John</FIRST_NAME>
  <LAST_NAME>Russell</LAST_NAME>
  <EMAIL>JRUSSEL</EMAIL>
  <PHONE_NUMBER>011.44.1344.429268</PHONE_NUMBER>
  <HIRE_DATE>01-OCT-04</HIRE_DATE>
  <JOB_ID>SA_MAN</JOB_ID>
  <SALARY>14000</SALARY>
  <COMMISSION_PCT>.4</COMMISSION_PCT>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
</ROWSET>
PL/SQL procedure successfully completed.
```

SYS_XMLAGG Oracle SQL Function

Oracle SQL function `sys_XMLAgg` aggregates all XML documents or fragments represented by an expression, producing a single XML document from them. It wraps the results of the expression in a new element named `ROWSET` (by default).

Oracle function `sys_XMLAgg` is similar to standard SQL/XML function `XMLAgg`, but `sys_XMLAgg` returns a single node and it accepts an `XMLFormat` parameter. You can use that parameter to format the resulting XML document in various ways.

Figure 8–14 SYS_XMLAGG Syntax

See Also:

- *Oracle Database SQL Language Reference* for information about `sys_XMLAgg`
- *Oracle Database SQL Language Reference* for information about an `XMLFormat` parameter

Guidelines for Generating XML with Oracle XML DB

This section describes additional guidelines for generating XML using Oracle XML DB.

Ordering Query Results Before Aggregating, Using XMLAGG ORDER BY Clause

To use the `XMLAgg ORDER BY` clause before aggregation, specify the `ORDER BY` clause following the first `XMLAGG` argument. This is illustrated in Example 8–31.

Example 8–31 Using XMLAGG ORDER BY Clause

```
CREATE TABLE dev_tab (dev         NUMBER,
                      dev_total   NUMBER,
                      devname     VARCHAR2(20));
Table created.
INSERT INTO dev_tab VALUES (16, 5,  'Alexis');
1 row created.
INSERT INTO dev_tab VALUES (2,  14, 'Han');
1 row created.
INSERT INTO dev_tab VALUES (1,  2,  'Jess');
1 row created.
INSERT INTO dev_tab VALUES (9,  88, 'Kurt');
1 row created.
COMMIT;
```

The result of the following query is aggregated according to the order of the `dev` column. (The result is shown here pretty-printed, for clarity.)

```
SELECT XMLAgg(XMLElement("Dev",
                         XMLAttributes(dev AS "id", dev_total AS "total"),
                         devname)
              ORDER BY dev)
  FROM dev_tab dev_total;

XMLAGG(XMLELEMENT("DEV",XMLATTRIBUTES(DEVAS"ID",DEV_TOTALAS"TOTAL"),DEVNAME)ORDE
--------------------------------------------------------------------------------
<Dev id="1" total="2">Jess</Dev>
<Dev id="2" total="14">Han</Dev>
<Dev id="9" total="88">Kurt</Dev>
<Dev id="16" total="5">Alexis</Dev>
```

```
1 row selected.
```

Returning a Rowset Using XMLTABLE

You can use standard SQL/XML function `XMLTable` to return a rowset with relevant portions of a document extracted as multiple rows, as shown in Example 8–32.

Example 8–32 Returning a Rowset Using XMLTABLE

```
CONNECT oe
Enter password: password

Connected.

SELECT item.descr, item.partid
  FROM purchaseorder,
       XMLTable('$p/PurchaseOrder/LineItems/LineItem' PASSING OBJECT_VALUE
                COLUMNS descr  VARCHAR2(256) PATH 'Description',
                        partid VARCHAR2(14)  PATH 'Part/@Id') item
  WHERE item.partid = '715515012027'
     OR item.partid = '715515011921'
  ORDER BY partid;
```

This returns a rowset with just the descriptions and part IDs, ordered by part ID.

```
DESCR
--------------
PARTID
--------------
My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027
```

```
Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

16 rows selected.
```

9

Relational Views over XML Data

This chapter describes the creation, indexing and querying of relational views over XML data. It contains these topics:

- Introduction to Creating and Using Relational Views over XML Data
- Creating a Relational View over XML: One Row for Each XML Document
- Creating a Relational View over XML: Mapping XML Nodes to Columns
- Indexing Binary XML Data Exposed Using a Relational View
- Querying XML Content As Relational Data

Introduction to Creating and Using Relational Views over XML Data

You can use the XML-specific functions and methods provided by Oracle XML DB to create conventional database views that provide relational access to XML content. This lets programmers, tools, and applications that understand Oracle Database, but not necessarily XML, work with XML content stored in the database.

The relational views can use XPath expressions and SQL/XML functions such as `XMLTable` to define a mapping between columns in the view and nodes in an XML document.

See Also:

- Chapter 4, "XQuery and Oracle XML DB"
- Chapter 6, "Indexes for XMLType Data"

Creating a Relational View over XML: One Row for Each XML Document

To expose each document in an `XMLType` table as a row in a relational view, use `CREATE OR REPLACE VIEW AS SELECT`, selecting from a join of the `XMLType` table and a relational table that you create from the XML data using SQL/XML function `XMLTable`. You use `XMLTable` to map nodes in the XML document to columns in the view.

You can use this technique whenever there is a one-to-*one* (1:1) relationship between documents in the `XMLType` table and the rows in the view.

Example 9–1 creates relational view `purchaseorder_master_view`, which has one row for each row in `XMLType` table `po_binaryxml`.

Example 9–1 Creating a Relational View of XML Content

```
CREATE TABLE po_binaryxml OF XMLType
  XMLTYPE STORE AS BINARY XML;
```

```
INSERT INTO po_binaryxml SELECT OBJECT_VALUE FROM OE.purchaseorder;

CREATE OR REPLACE VIEW purchaseorder_master_view AS
  SELECT po.*
    FROM po_binaryxml pur,
         XMLTable(
           '$p/PurchaseOrder' PASSING pur.OBJECT_VALUE as "p"
           COLUMNS
             reference       VARCHAR2(30)   PATH 'Reference',
             requestor       VARCHAR2(128)  PATH 'Requestor',
             userid          VARCHAR2(10)   PATH 'User',
             costcenter      VARCHAR2(4)    PATH 'CostCenter',
             ship_to_name    VARCHAR2(20)   PATH 'ShippingInstructions/name',
             ship_to_address VARCHAR2(256)  PATH 'ShippingInstructions/address',
             ship_to_phone   VARCHAR2(24)   PATH 'ShippingInstructions/telephone',
             instructions    VARCHAR2(2048) PATH 'SpecialInstructions') po;

View created.

DESCRIBE purchaseorder_master_view

Name            Null?    Type
----------------------------------------------
REFERENCE                VARCHAR2(30)
REQUESTOR                VARCHAR2(128)
USERID                   VARCHAR2(10)
COSTCENTER               VARCHAR2(4)
SHIP_TO_NAME             VARCHAR2(20)
SHIP_TO_ADDRESS          VARCHAR2(256)
SHIP_TO_PHONE            VARCHAR2(24)
INSTRUCTIONS             VARCHAR2(2048)
```

Creating a Relational View over XML: Mapping XML Nodes to Columns

When you need to expose data contained at multiple levels in an `XMLType` table as individual rows in a relational view, you use the same general approach as for breaking up a single level (see "Creating a Relational View over XML: One Row for Each XML Document" on page 9-1): Define the columns making up the view and map the XML nodes to those columns.

But in this case you apply SQL/XML function `XMLTable` to each document level that is to be broken up and stored in relational columns. Use this technique whenever there is a one-to-*many* (1:N) relationship between documents in the `XMLType` table and the rows in the relational view.

For example, each `PurchaseOrder` element contains a `LineItems` element, which in turn contains one or more `LineItem` elements. Each `LineItem` element has child elements, such as `Description`, and an `ItemNumber` attribute. To make such lower-level data accessible as a relational value, use `XMLTable` to project both the `PurchaseOrder` element and the `LineItem` collection.

When element `PurchaseOrder` is broken up, its descendant `LineItem` element is mapped to a column of type `XMLType`, which contains an XML fragment. That column is then passed to a second call to `XMLTable` to be broken into its various parts as multiple columns of relational values.

Example 9–2 illustrates this. It uses `XMLTable` to effect a one-to-*many* (1:N) relationship between the documents in `XMLType` table `po_binaryxml` and the rows in relational view

purchaseorder_detail_view. The view provides access to the individual members of a collection and exposes the collection members as a set of rows.

Example 9–2 Accessing Individual Members of a Collection Using a View

```
CREATE OR REPLACE VIEW purchaseorder_detail_view AS
  SELECT po.reference, li.*
    FROM po_binaryxml p,
         XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                  COLUMNS
                    reference VARCHAR2(30) PATH 'Reference',
                    lineitem  XMLType      PATH 'LineItems/LineItem') po,
         XMLTable('/LineItem' PASSING po.lineitem
                  COLUMNS
                    itemno      NUMBER(38)    PATH '@ItemNumber',
                    description VARCHAR2(256) PATH 'Description',
                    partno      VARCHAR2(14)  PATH 'Part/@Id',
                    quantity    NUMBER(12, 2) PATH 'Part/@Quantity',
                    unitprice   NUMBER(8, 4)  PATH 'Part/@UnitPrice') li;

View created.

DESCRIBE purchaseorder_detail_view
Name           Null?    Type
----------------------------
REFERENCE               VARCHAR2(30)
ITEMNO                  NUMBER(38)
DESCRIPTION             VARCHAR2(256)
PARTNO                  VARCHAR2(14)
QUANTITY                NUMBER(12,2)
UNITPRICE               NUMBER(8,4)
```

In Example 9–2, there is one row in view purchaseorder_detail_view for each LineItem element in the XML documents stored in XMLType table po_binaryxml.

The CREATE OR REPLACE VIEW statement of Example 9–2 defines the set of relational columns that make up the view. The SELECT statement passes table po_binaryxml as context to function XMLTable to create virtual table p, which has columns reference and lineitem. These columns contain the Reference and LineItem elements of the purchase-order documents, respectively.

Column lineitem contains a collection of LineItem elements as an XMLType instance—one row for each element. These rows are in turn passed to a second XMLTable expression to serve as its context. This second XMLTable expression creates a virtual table of line-item rows, with columns corresponding to various descendant nodes of element LineItem. Most of these descendants are attributes (ItemNumber, Part/@Id, and so on). One of the descendants is the child element Description.

Element Reference is projected in view purchaseorder_detail_view as column reference. It provides a foreign key that can be used to join rows in view purchaseorder_detail_view to corresponding rows in view purchaseorder_master_view. The correlated join in the CREATE OR REPLACE VIEW statement ensures that the one-to-many (1:N) relationship between element Reference and the associated LineItem elements is maintained whenever the view is accessed.

Indexing Binary XML Data Exposed Using a Relational View

When the XMLType data that is exposed in a relational view is stored as binary XML, you can typically improve performance by creating an XMLIndex index that has a

structured component that matches the view columns. Such an index projects parts of the XML data onto relational columns, just as the view does. When the columns of the index match the columns of the view, the view is effectively indexed.

To simplify the creation of such an `XMLIndex` index, you can use PL/SQL function `DBMS_XMLSTORAGE_MANAGE.getSIDXDefFromView` to provide exactly the `XMLTable` expression needed for creating the index. That is the sole purpose of this function: to return an `XMLTable` expression that you can use to create an `XMLIndex` index for a relational view. It takes the view as argument and returns a `CLOB` instance. Example 9–3 illustrates this.

Example 9–3 XMLIndex Index that Matches Relational View Columns

```
CALL DBMS_XMLINDEX.registerParameter(
  'my_param',
  DBMS_XMLSTORAGE_MANAGE.getSIDXDefFromView('PURCHASEORDER_MASTER_VIEW'));[1]

CREATE INDEX my_idx on po_binaryxml (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('PARAM my_param');
```

Example 9–4 shows the `XMLTable` expression used in Example 9–3.

Example 9–4 XMLTable Expression Returned by PL/SQL Function getSIDXDefFromView

```
SELECT DBMS_XMLSTORAGE_MANAGE.getSIDXDefFromView('PURCHASEORDER_MASTER_VIEW')
  FROM DUAL;

XMLTABLE po_binaryxml_XTAB_1 '/PurchaseOrder' PASSING OBJECT_VALUE
  COLUMNS
    reference       VARCHAR2   (30) PATH 'Reference',
    requestor       VARCHAR2  (128) PATH 'Requestor',
    userid          VARCHAR2   (10) PATH 'User',
    costcenter      VARCHAR2    (4) PATH 'CostCenter',
    ship_to_name    VARCHAR2   (20) PATH 'ShippingInstructions/name',
    ship_to_address VARCHAR2  (256) PATH 'ShippingInstructions/address',
    ship_to_phone   VARCHAR2   (24) PATH 'ShippingInstructions/telephone',
    instructions    VARCHAR2 (2048) PATH 'SpecialInstructions'
```

See Also:

- "Using XMLIndex with a Structured Component" on page 6-22
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL function `DBMS_XMLSTORAGE_MANAGE.getSIDXDefFromView`

Querying XML Content As Relational Data

The examples in this section show relational queries of XML data. They point out some of the benefits provided by creating relational views over `XMLType` tables and columns.

Example 9–5 and Example 9–6 show how to query master and detail relational views of XML data. Example 9–5 queries the master view to select the rows where column `userid` starts with `S`.

[1] The view-name argument to `getSIDXDefFromView` must be uppercase, since that is how the name is recorded.

Example 9–5 Querying Master Relational View of XML Data

```
SELECT reference, costcenter, ship_to_name
  FROM purchaseorder_master_view
  WHERE userid LIKE 'S%';

REFERENCE                      COST SHIP_TO_NAME
------------------------------ ---- --------------
SBELL-20021009123336231PDT     S30  Sarah J. Bell
SBELL-20021009123336331PDT     S30  Sarah J. Bell
SKING-20021009123336321PDT     A10  Steven A. King
...
36 rows selected.
```

Example 9–6 joins the master view and the detail view. It selects the `purchaseorder_detail_view` rows where the value of column `itemno` is `1` and the corresponding `purchaseorder_master_view` row contains a `userid` column with the value `SBELL`.

Example 9–6 Querying Master and Detail Relational Views of XML Data

```
SELECT d.reference, d.itemno, d.partno, d.description
  FROM purchaseorder_detail_view d, purchaseorder_master_view m
  WHERE m.reference = d.reference
    AND m.userid = 'SBELL'
    AND d.itemno = 1;

REFERENCE                      ITEMNO PARTNO         DESCRIPTION
------------------------------ ------ -------------- ----------------------------------------
SBELL-20021009123336231PDT          1 37429165829    Juliet of the Spirits
SBELL-20021009123336331PDT          1 715515009225   Salo
SBELL-20021009123337353PDT          1 37429141625    The Third Man
SBELL-20021009123338304PDT          1 715515009829   Nanook of the North
SBELL-20021009123338505PDT          1 37429122228    The 400 Blows
SBELL-20021009123335771PDT          1 37429139028    And the Ship Sails on
SBELL-20021009123335280PDT          1 715515011426   All That Heaven Allows
SBELL-2002100912333763PDT           1 715515010320   Life of Brian - Python
SBELL-2002100912333601PDT           1 715515009058   A Night to Remember
SBELL-20021009123336362PDT          1 715515012928   In the Mood for Love
SBELL-20021009123336532PDT          1 37429162422    Wild Strawberries
SBELL-20021009123338204PDT          1 37429168820    Red Beard
SBELL-20021009123337673PDT          1 37429156322    Cries and Whispers

13 rows selected.
```

Example 9–7 shows how to use relational views over XML content to perform business-intelligence queries on XML documents. The example query selects `PurchaseOrder` documents that contain orders for titles identified by UPC codes `715515009058` and `715515009126`.

Example 9–7 Business-Intelligence Query of XML Data Using a View

```
SELECT partno, count(*) "No of Orders", quantity "No of Copies"
  FROM purchaseorder_detail_view
  WHERE partno IN (715515009126, 715515009058)
  GROUP BY rollup(partno, quantity);

PARTNO         No of Orders No of Copies
-------------- ------------ ------------
715515009058              7            1
715515009058              9            2
715515009058              5            3
```

```
715515009058              2            4
715515009058             23
715515009126              4            1
715515009126              7            3
715515009126             11
                         34
9 rows selected.
```

The query in Example 9–7 determines the number of copies of each film title that are ordered in each `PurchaseOrder` document. For example, for part number `715515009126`, there are four `PurchaseOrder` documents where one copy of the item is ordered and seven `PurchaseOrder` documents where three copies of the item are ordered.

10

XMLType Views

This chapter describes how to create and use XMLType views. It contains these topics:

What Are XMLType Views?

XMLType views wrap existing relational and object-relational data in XML formats. The major advantages of using XMLType views are:

- You can exploit Oracle XML DB XML features that use XML schema functionality without having to migrate your base legacy data.
- With XMLType views, you can experiment with various forms of storage for your data. You need not decide immediately whether to store it as XMLType or which XMLType storage model to use.

XMLType views are similar to object views. Each row of an XMLType view corresponds to an XMLType instance. The object identifier for uniquely identifying each row in the view can be created using SQL/XML functions XMLCast and XMLQuery.

Throughout this chapter XML schema refers to the W3C XML Schema 1.0 recommendation, http://www.w3.org/XML/Schema.

There are two types of XMLType views:

- **Non-schema-based XMLType views.** These views do not confirm to a particular XML schema.
- **XML schema-based XMLType views.** As with XMLType tables, XMLType views that conform to a particular XML schema are called XML schema-based XMLType views. These provide stronger typing than non-schema-based XMLType views.

XPath rewrite of queries over XMLType views is enabled for both XML schema-based and non-schema-based XMLType views. XPath rewrite is described in Chapter 19, "XPath Rewrite for Object-Relational Storage".

To create an XML schema-based XMLType view, first register your XML schema. If the view is an object view, that is, if it is constructed using an object type, then the XML schema should have annotations that represent the bidirectional mapping from XML

to SQL object types. XMLType views conforming to this registered XML schema can then be created by providing an underlying query that constructs instances of the appropriate SQL object type.

See Also:

- Chapter 17, "XML Schema Storage and Query: Basic"
- Chapter 9, "Relational Views over XML Data"
- Chapter 16, "Choice of XMLType Storage and Indexing"

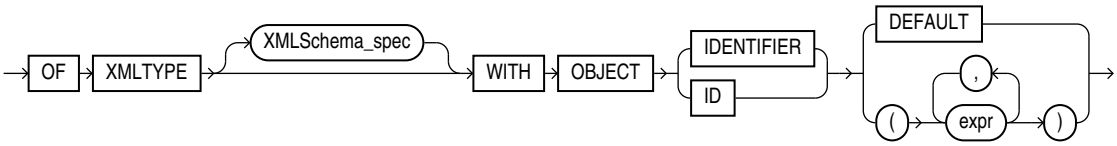
You can create XMLType views in any of the following ways:

- Based on SQL/XML publishing functions, such as XMLElement, XMLForest, XMLConcat, and XMLAgg. SQL/XML publishing functions can be used to construct both non-schema-based XMLType views and XML schema-based XMLType views. This enables construction of XMLType view from the underlying relational tables directly without physically migrating those relational legacy data into XML. However, to construct XML schema-based XMLType view, the XML schema must be registered and the XML value generated by SQL/XML publishing functions must be constrained to the XML schema.
- Based on object types or object views. This enables the construction of the XMLType view from underlying relational or object relational tables directly without physically migrating the relational or object relational legacy data into XML. Creating an XML-schema-based XMLType view requires that you annotate the XML schema with a mapping to existing object types or that you generate the XML schema from the existing object types.
- Directly from an XMLType table.

CREATE VIEW for XMLType Views: Syntax

Figure 10–1 shows the CREATE VIEW clause for creating XMLType views. See *Oracle Database SQL Language Reference* for details on the CREATE VIEW syntax.

Figure 10–1 Creating XMLType Views Clause: Syntax



Creating Non-Schema-Based XMLType Views

The XML data in non-schema-based XMLType views is not constrained to conform to a registered XML schema. You can create a non-schema-based XMLType view using SQL/XML publishing functions.

Example 10–1 shows how to create an XMLType view using SQL/XML function XMLELement.

Example 10–1 Creating an XMLType View Using XMLELEMENT

```
CREATE OR REPLACE VIEW emp_view OF XMLType
  WITH OBJECT ID (XMLCast(XMLQuery('/Emp/@empno'
                                   PASSING OBJECT_VALUE RETURNING CONTENT)
```

```
                        AS BINARY_DOUBLE)) AS
  SELECT XMLElement("Emp",
                    XMLAttributes(employee_id AS "empno"),
                    XMLForest(e.first_name ||' '|| e.last_name AS "name",
                              e.hire_date AS "hiredate"))
    AS "result" FROM employees e WHERE salary > 15000;

SELECT * FROM emp_view;

SYS_NC_ROWINFO$
--------------------------------------------------------------------------------
<Emp empno="100"><name>Steven King</name><hiredate>2003-06-17</hiredate></Emp>
<Emp empno="101"><name>Neena Kochhar</name><hiredate>2005-09-21</hiredate></Emp>
<Emp empno="102"><name>Lex De Haan</name><hiredate>2001-01-13</hiredate></Emp>
```

Existing data in relational tables or views can be exposed as XML this way. If a view is generated using a SQL/XML publishing function, then queries that access that view using XPath expressions can often be rewritten. These optimized queries can then directly access the underlying relational columns. See Chapter 19, "XPath Rewrite for Object-Relational Storage" for details.

You can perform DML operations on these `XMLType` views, but, in general, you must write instead-of triggers to handle the DML operation.

> **See Also:** Chapter 8, "Generation of XML Data from Relational Data", for details on SQL/XML publishing functions

Creating XML Schema-Based XMLType Views

XML schema-based `XMLType` views are views whose data is constrained to conform to an XML schema. You can create an XML schema-based `XMLType` view in either of these ways:

- Using SQL/XML publishing functions.

  > **See Also:** "Creating XML Schema-Based XMLType Views Using SQL/XML Publishing Functions" on page 10-3

- Using object types or object views. This is convenient when you already have object types, views, and tables that you want to map to XML data.

  > **See Also:** "Creating XML Schema-Based XMLType Views Using Object Types or Object Views" on page 10-9

Creating XML Schema-Based XMLType Views Using SQL/XML Publishing Functions

You can use SQL/XML publishing functions to create XML schema-based `XMLType` views in a similar way as for the non-schema-based case described in section "Creating Non-Schema-Based XMLType Views":

1. Create and register the XML schema document that contains the necessary XML structures. You do not need to annotate the XML schema to define the mapping between XML types and SQL object types.
2. Use SQL/XML publishing functions to create an `XMLType` view that conforms to the XML schema.

These two steps are illustrated in Example 10–2 and Example 10–3, respectively.

Example 10–2 Registering XML Schema emp_simple.xsd

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
   SCHEMAURL => 'http://www.oracle.com/emp_simple.xsd',
   SCHEMADOC => '<schema xmlns="http://www.w3.org/2001/XMLSchema"
                         targetNamespace="http://www.oracle.com/emp_simple.xsd"
                         version="1.0"
                         xmlns:xdb="http://xmlns.oracle.com/xdb"
                         elementFormDefault="qualified">
                    <element name = "Employee">
                      <complexType>
                        <sequence>
                          <element name = "EmployeeId"
                                   type = "positiveInteger" minOccurs = "0"/>
                          <element name = "Name"
                                   type = "string" minOccurs = "0"/>
                          <element name = "Job"
                                   type = "string" minOccurs = "0"/>
                          <element name = "Manager"
                                   type = "positiveInteger" minOccurs = "0"/>
                          <element name = "HireDate"
                                   type = "date" minOccurs = "0"/>
                          <element name = "Salary"
                                   type = "positiveInteger" minOccurs = "0"/>
                          <element name = "Commission"
                                   type = "positiveInteger" minOccurs = "0"/>
                          <element name = "Dept">
                            <complexType>
                              <sequence>
                                <element name = "DeptNo"
                                         type = "positiveInteger" minOccurs = "0"/>
                                <element name = "DeptName"
                                         type = "string" minOccurs = "0"/>
                                <element name = "Location"
                                         type = "positiveInteger" minOccurs = "0"/>
                              </sequence>
                            </complexType>
                          </element>
                        </sequence>
                      </complexType>
                    </element>
                  </schema>',
   LOCAL     => TRUE,
   GENTYPES  => TRUE);
END;
```

Example 10–2 assumes that you have an XML schema `emp_simple.xsd` that contains XML structures defining an employee. It registers the XML schema with the target location `http://www.oracle.com/emp_simple.xsd`.

When using SQL/XML publishing functions to generate XML schema-based content, you must specify the appropriate namespace information for all of the elements and also indicate the location of the schema using attribute `xsi:schemaLocation`. These can be specified using the `XMLAttributes` clause. Example 10–3 illustrates this.

Example 10–3 Creating an XMLType View Using SQL/XML Publishing Functions

```
CREATE OR REPLACE VIEW emp_simple_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/emp_simple.xsd" ELEMENT "Employee"
   WITH OBJECT ID (XMLCast(XMLQuery('/Employee/EmployeeId/text()'
```

```
                                    PASSING OBJECT_VALUE
                                    RETURNING CONTENT)
                             AS BINARY_DOUBLE)) AS
  SELECT
    XMLElement("Employee",
               XMLAttributes(
                 'http://www.oracle.com/emp_simple.xsd' AS "xmlns" ,
                 'http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
                 'http://www.oracle.com/emp_simple.xsd
                  http://www.oracle.com/emp_simple.xsd'
                AS "xsi:schemaLocation"),
               XMLForest(e.employee_id    AS "EmployeeId",
                         e.last_name      AS "Name",
                         e.job_id         AS "Job",
                         e.manager_id     AS "Manager",
                         e.hire_date      AS "HireDate",
                         e.salary         AS "Salary",
                         e.commission_pct AS "Commission",
                         XMLForest(
                           d.department_id   AS "DeptNo",
                           d.department_name AS "DeptName",
                           d.location_id     AS "Location") AS "Dept"))
    FROM employees e, departments d
    WHERE e.department_id = d.department_id;
```

In Example 10–3, function `XMLElement` creates XML element `Employee`. Function `XMLForest` creates the children of element `Employee`. The `XMLAttributes` clause inside `XMLElement` constructs the required XML `namespace` and schema `location` attributes, so that the XML data that is generated conforms to the XML schema of the view. The innermost call to `XMLForest` creates the children of element `department`, which is a child of element `Employee`.

By default, the XML generation functions create a non-schema-based XML instance. However, when the schema location is specified, using attribute `xsi:schemaLocation` or `xsi:noNamespaceSchemaLocation`, Oracle XML DB generates XML schema-based XML data. For `XMLType` views, as long as the names of the elements and attributes match those in the XML schema, the XML data is converted implicitly into a valid XML schema-based document. Any errors in the generated XML data are caught later, when operations such as validation or extraction operations are performed on the XML instance.

Example 10–4 queries the `XMLType` view, returning an XML result from tables `employees` and `departments`. The result of the query is shown pretty-printed, for clarity.

Example 10–4 Querying an XMLType View

```
SELECT OBJECT_VALUE AS RESULT FROM emp_simple_xml WHERE ROWNUM < 2;

RESULT
--------------------------------------------------------------------
<Employee xmlns="http://www.oracle.com/emp_simple.xsd"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="http://www.oracle.com/emp_simple.xsd
                              http://www.oracle.com/emp_simple.xsd">
  <EmployeeId>200</EmployeeId>
  <Name>Whalen</Name>
  <Job>AD_ASST</Job>
  <Manager>101</Manager>
  <HireDate>2003-09-17</HireDate>
```

```
  <Salary>4400</Salary>
  <Dept>
    <DeptNo>10</Deptno>
    <DeptName>Administration</DeptName>
    <Location>1700</Location>
  </Dept>
</Employee>
```

Using Namespaces with SQL/XML Publishing Functions

If you have complex XML schemas involving namespaces, you must use the partially escaped mapping provided by the SQL/XML publishing functions and create elements with appropriate namespaces and prefixes.

The query in Example 10–5 creates XML instances that have the correct namespace, prefixes, and target schema location. It can be used as the query in the definition of view `emp_simple_xml`.

Example 10–5 Using Namespace Prefixes with SQL/XML Publishing Functions

```
SELECT XMLElement("ipo:Employee",
          XMLAttributes('http://www.oracle.com/emp_simple.xsd' AS "xmlns:ipo",
                        'http://www.oracle.com/emp_simple.xsd
                         http://www.oracle.com/emp_simple.xsd' AS "xmlns:xsi"),
            XMLForest(e.employee_id                     AS "ipo:EmployeeId",
                      e.last_name                       AS "ipo:Name",
                      e.job_id                          AS "ipo:Job",
                      e.manager_id                      AS "ipo:Manager",
                      TO_CHAR(e.hire_date,'YYYY-MM-DD') AS "ipo:HireDate",
                      e.salary                          AS "ipo:Salary",
                      e.commission_pct                  AS "ipo:Commission",
                   XMLForest(d.department_id   AS "ipo:DeptNo",
                             d.department_name AS "ipo:DeptName", d.location_id
       AS "ipo:Location") AS "ipo:Dept"))
       FROM employees e, departments d
       WHERE e.department_id = d.department_id AND d.department_id = 20;
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('emp-noname.xsd', 4);
END;

XMLELEMENT("IPO:EMPLOYEE",XMLATTRIBUTES('HTTP://WWW.ORACLE.COM/EMP_SIMPLE.XSD'AS
--------------------------------------------------------------------------------
<ipo:Employee
xmlns:ipo="http://www.oracle.com/emp_simple.xsd"
 xmlns:xsi="http://www.oracle.com/emp_simple.xsd
 http://www.oracle.com/emp_simple.xsd">
<ipo:EmployeeId>201</ipo:EmployeeId><ipo:Name>Hartstein</ipo:Name>
<ipo:Job>MK_MAN</ipo:Job><ipo:Manager>100</ipo:Manager>
<ipo:HireDate>2004-02-17</ipo:HireDate><ipo:Salary>13000</ipo:Salary>
<ipo:Dept><ipo:DeptNo>20</ipo:DeptNo><ipo:DeptName>Marketing</ipo:DeptName>
<ipo:Location>1800</ipo:Location></ipo:Dept></ipo:Employee>
<ipo:Employee xmlns:ipo="http://www.oracle.com/emp_simple.xsd"
 xmlns:xsi="http://www.oracle.com/emp_simple.xsd
 http://www.oracle.com/emp_simple.xsd"><ipo:EmployeeId>202</ipo:EmployeeId>
<ipo:Name>Fay</ipo:Name><ipo:Job>MK_REP</ipo:Job><ipo:Manager>201</ipo:Manager>
<ipo:HireDate>2005-08-17</ipo:HireDate><ipo:Salary>6000</ipo:Salary>
<ipo:Dept><ipo:DeptNo>20</ipo:Dept
No><ipo:DeptName>Marketing</ipo:DeptName><ipo:Location>1800</ipo:Location>
</ipo:Dept>
</ipo:Employee>
```

If the XML schema had no target namespace, then you could use attribute `xsi:noNamespaceSchemaLocation` to indicate that. Example 10–6 shows such an XML schema.

Example 10–6 XML Schema with No Target Namespace

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'emp-noname.xsd',
    SCHEMADOC => '<schema xmlns="http://www.w3.org/2001/XMLSchema"
                          xmlns:xdb="http://xmlns.oracle.com/xdb">
                    <element name = "Employee">
                      <complexType>
                        <sequence>
                          <element name = "EmployeeId" type = "positiveInteger"/>
                          <element name = "Name" type = "string"/>
                          <element name = "Job" type = "string"/>
                          <element name = "Manager" type = "positiveInteger"/>
                          <element name = "HireDate" type = "date"/>
                          <element name = "Salary" type = "positiveInteger"/>
                          <element name = "Commission" type = "positiveInteger"/>
                          <element name = "Dept">
                            <complexType>
                              <sequence>
                                <element name = "DeptNo" type = "positiveInteger" />
                                <element name = "DeptName" type = "string"/>
                                <element name = "Location" type = "positiveInteger"/>
                              </sequence>
                            </complexType>
                          </element>
                        </sequence>
                      </complexType>
                    </element>
                  </schema>',
    LOCAL     => TRUE,
    GENTYPES  => TRUE);
END;
```

Example 10–7 creates a view that conforms to the XML schema in Example 10–6. The `XMLAttributes` clause creates an XML element that contains the `noNamespace` schema location attribute.

Example 10–7 Creating a View for an XML Schema with No Target Namespace

```
CREATE OR REPLACE VIEW emp_xml OF XMLType
     XMLSCHEMA "emp-noname.xsd" ELEMENT "Employee"
     WITH OBJECT ID (XMLCast(XMLQuery('/Employee/EmployeeId/text()'
                                      PASSING OBJECT_VALUE
                                      RETURNING CONTENT)
                             AS BINARY_DOUBLE)) AS
     SELECT XMLElement(
       "Employee",
       XMLAttributes('http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
                     'emp-noname.xsd' AS "xsi:noNamespaceSchemaLocation"),
       XMLForest(e.employee_id    AS "EmployeeId",
                 e.last_name      AS "Name",
                 e.job_id         AS "Job",
                 e.manager_id     AS "Manager",
                 e.hire_date      AS "HireDate",
```

```
                              e.salary         AS "Salary",
                              e.commission_pct AS "Commission",
                              XMLForest(d.department_id   AS "DeptNo",
                                        d.department_name AS "DeptName",
                                        d.location_id     AS "Location") AS "Dept"))
                       FROM employees e, departments d
                       WHERE e.department_id = d.department_id;
```

Example 10–8 creates view `dept_xml`, which conforms to XML schema `dept.xsd`.

Example 10–8 Using SQL/XML Functions in XML Schema-Based XMLType Views

```
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/dept.xsd', 4);
END;
/

BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/dept.xsd',
    SCHEMADOC => '<schema xmlns="http://www.w3.org/2001/XMLSchema"
                          targetNamespace="http://www.oracle.com/dept.xsd"
                          version="1.0"
                          xmlns:xdb="http://xmlns.oracle.com/xdb"
                          elementFormDefault="qualified">
                    <element name = "Department">
                      <complexType>
                        <sequence>
                          <element name = "DeptNo" type = "positiveInteger"/>
                          <element name = "DeptName" type = "string"/>
                          <element name = "Location" type = "positiveInteger"/>
                          <element name = "Employee" maxOccurs = "unbounded">
                            <complexType>
                              <sequence>
                                <element name = "EmployeeId" type = "positiveInteger"/>
                                <element name = "Name" type = "string"/>
                                <element name = "Job" type = "string"/>
                                <element name = "Manager" type = "positiveInteger"/>
                                <element name = "HireDate" type = "date"/>
                                <element name = "Salary" type = "positiveInteger"/>
                                <element name = "Commission" type = "positiveInteger"/>
                              </sequence>
                            </complexType>
                          </element>
                        </sequence>
                      </complexType>
                    </element>
                  </schema>',
    LOCAL     => TRUE,
    GENTYPES  => FALSE);
  END;
/

CREATE OR REPLACE VIEW dept_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/dept.xsd" ELEMENT "Department"
  WITH OBJECT ID (XMLCast(XMLQuery('/Department/DeptNo'
                                   PASSING OBJECT_VALUE RETURNING CONTENT)
                          AS BINARY_DOUBLE)) AS
  SELECT XMLElement(
```

```
    "Department",
    XMLAttributes(
      'http://www.oracle.com/emp.xsd' AS "xmlns" ,
      'http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
      'http://www.oracle.com/dept.xsd
       http://www.oracle.com/dept.xsd' AS "xsi:schemaLocation"),
    XMLForest(d.department_id "DeptNo",
              d.department_name "DeptName",
              d.location_id "Location"),
    (SELECT XMLagg(
              XMLElement("Employee",
                         XMLForest(
                           e.employee_id  "EmployeeId",
                           e.last_name "Name",
                           e.job_id "Job",
                           e.manager_id "Manager",
                           to_char(e.hire_date,'YYYY-MM-DD') "Hiredate",
                           e.salary "Salary",
                           e.commission_pct "Commission")))
       FROM employees e
       WHERE e.department_id = d.department_id))
     FROM departments d;
```

This is the `XMLType` instance that results:

```
SELECT OBJECT_VALUE AS result FROM dept_xml WHERE ROWNUM < 2;

RESULT
--------------------------------------------------------------------
<Department
    xmlns="http://www.oracle.com/emp.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.oracle.com/dept.xsd
                        http://www.oracle.com/dept.xsd">
  <DeptNo>10</DeptNo>
  <DeptName>Administration</DeptName>
  <Location>1700</Location>
  <Employee>
    <EmployeeId>200</EmployeeId>
    <Name>Whalen</Name>
    <Job>AD_ASST</Job>
    <Manager>101</Manager>
    <Hiredate>2003-09-17</Hiredate>
    <Salary>4400</Salary>
  </Employee>
</Department>
```

Creating XML Schema-Based XMLType Views Using Object Types or Object Views

To create an XML schema-based `XMLType` view from object types or object views, do the following:

1. Create the object types, if they do not yet exist.
2. Create and then register the XML schema, annotating it to define the mapping between XML types and SQL object types and attributes.

   Annotate the XML schema *before* registering it. You typically do this when you wrap existing data to create an `XMLType` view.

When such an XML schema document is registered, the following validation can occur:

- `SQLType` for attributes or elements based on `simpleType`. The SQL type must be compatible with the XML type of the corresponding `XMLType` data. For example, an XML `string` data type can be mapped only to a `VARCHAR2` or a Large Object (LOB) data type.
- `SQLType` specified for elements based on `complexType`. This is either a LOB or an object type whose structure must be compatible with the declaration of the `complexType`, that is, the object type must have the correct number of attributes with the correct data types.

  See: Chapter 17, "XML Schema Storage and Query: Basic"

3. Create the `XMLType` view, specifying the XML schema URL and the root element name. The query defining the view first constructs the object instances and then converts them to XML.
   a. Create an object view.
   b. Create an `XMLType` view over the object view.

The following sections present examples of creating XML schema-based `XMLType` views using object types or object views. They are based on relational tables that contain employee and department data.

- "Creating XMLType Employee View, with Nested Department Information"
- "Creating XMLType Department View, with Nested Employee Information"

The same relational data is used to create each of two `XMLType` views. In the employee view, `emp_xml`, the XML document describes an employee, with the employee's department as nested information. In the department view, `dept_xml`, the XML data describes a department, with the department's employees as nested information.

Creating XMLType Employee View, with Nested Department Information

This section describes how to create `XMLType` view `emp_xml` based on object views. For the last step, there are two *alternatives*:

- "Step 3a. Create XMLType View emp_xml Using Object Type emp_t" – create `XMLType` view `emp_xml` using object type `emp_t`
- "Step 3b. Create XMLType View emp_xml Using Object View emp_v" – create `XMLType` view `emp_xml` using object view `emp_v`

Step 1. Create Object Types Example 10–9 creates the object types used in the other steps.

Example 10–9 Creating Object Types for Schema-Based XMLType Views

```
CREATE TYPE dept_t AS OBJECT
      (deptno NUMBER(4),
       dname  VARCHAR2(30),
       loc    NUMBER(4));
/

CREATE TYPE emp_t AS OBJECT
      (empno     NUMBER(6),
       ename     VARCHAR2(25),
       job       VARCHAR2(10),
```

```
        mgr       NUMBER(6),
        hiredate  DATE,
        sal       NUMBER(8,2),
        comm      NUMBER(2,2),
        dept      dept_t);
/
```

Step 2. Create and Register XML Schema emp_complex.xsd Create XML schema emp_xomplex.xsd, which specifies how XML elements and attributes are mapped to corresponding object attributes in the object types (the `xdb:SQLType` annotations), then register it. Example 10–10 registers it.

Example 10–10 Registering XML Schema emp_complex.xsd

```
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/emp_complex.xsd', 4);
END;
/

COMMIT;

BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/emp_complex.xsd',
    SCHEMADOC => '<?xml version="1.0"?>
                  <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                              xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                              xmlns:xdb="http://xmlns.oracle.com/xdb"
                              xsi:schemaLocation="http://xmlns.oracle.com/xdb
                                                  http://xmlns.oracle.com/xdb/XDBSchema.xsd">
                    <xsd:element name="Employee" type="EMP_TType" xdb:SQLType="EMP_T"/>
                    <xsd:complexType name="EMP_TType" xdb:SQLType="EMP_T" xdb:maintainDOM="false">
                      <xsd:sequence>
                        <xsd:element name="EMPNO" type="xsd:double" xdb:SQLName="EMPNO"
                                     xdb:SQLType="NUMBER"/>
                        <xsd:element name="ENAME" xdb:SQLName="ENAME" xdb:SQLType="VARCHAR2">
                          <xsd:simpleType>
                            <xsd:restriction base="xsd:string">
                              <xsd:maxLength value="25"/>
                            </xsd:restriction>
                          </xsd:simpleType>
                        </xsd:element>
                        <xsd:element name="JOB" xdb:SQLName="JOB" xdb:SQLType="VARCHAR2">
                          <xsd:simpleType>
                            <xsd:restriction base="xsd:string">
                              <xsd:maxLength value="10"/>
                            </xsd:restriction>
                          </xsd:simpleType>
                        </xsd:element>
                        <xsd:element name="MGR" type="xsd:double" xdb:SQLName="MGR"
                                     xdb:SQLType="NUMBER"/>
                        <xsd:element name="HIREDATE" type="xsd:date" xdb:SQLName="HIREDATE"
                                     xdb:SQLType="DATE"/>
                        <xsd:element name="SAL" type="xsd:double" xdb:SQLName="SAL"
                                     xdb:SQLType="NUMBER"/>
                        <xsd:element name="COMM" type="xsd:double" xdb:SQLName="COMM"
                                     xdb:SQLType="NUMBER"/>
                        <xsd:element name="DEPT" type="DEPT_TType" xdb:SQLName="DEPT"
                                     xdb:SQLType="DEPT_T"/>
```

```
                  </xsd:sequence>
                </xsd:complexType>
                <xsd:complexType name="DEPT_TType" xdb:SQLType="DEPT_T"
                                 xdb:maintainDOM="false">
                  <xsd:sequence>
                    <xsd:element name="DEPTNO" type="xsd:double" xdb:SQLName="DEPTNO"
                                 xdb:SQLType="NUMBER"/>
                    <xsd:element name="DNAME" xdb:SQLName="DNAME" xdb:SQLType="VARCHAR2">
                      <xsd:simpleType>
                        <xsd:restriction base="xsd:string">
                          <xsd:maxLength value="30"/>
                        </xsd:restriction>
                      </xsd:simpleType>
                    </xsd:element>
                   <xsd:element name="LOC" type="xsd:double" xdb:SQLName="LOC"
                               xdb:SQLType="NUMBER"/>
                  </xsd:sequence>
                </xsd:complexType>
              </xsd:schema>',
    LOCAL     => TRUE,
    GENTYPES  => FALSE);
END;
/
```

Example 10–10 registers the XML schema using the target location `http://www.oracle.com/emp_complex.xsd`.

Step 3a. Create XMLType View emp_xml Using Object Type emp_t Example 10–11 creates an `XMLType` view using object type `emp_t`.

Example 10–11 Creating XMLType View emp_xml

```
CREATE OR REPLACE VIEW emp_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/emp_complex.xsd"
  ELEMENT "Employee"
    WITH OBJECT ID (XMLCast(XMLQuery('/Employee/EMPNO'
                                     PASSING OBJECT_VALUE RETURNING CONTENT)
                            AS BINARY_DOUBLE)) AS
  SELECT emp_t(e.employee_id, e.last_name, e.job_id, e.manager_id, e.hire_date,
               e.salary, e.commission_pct,
               dept_t(d.department_id, d.department_name, d.location_id))
    FROM employees e, departments d
    WHERE e.department_id = d.department_id;
```

Example 10–11 uses SQL/XML function `XMLCast` in the `OBJECT ID` clause to convert the XML employee number to SQL data type `BINARY_DOUBLE`.

Step 3b. Create XMLType View emp_xml Using Object View emp_v Example 10–12 creates an `XMLType` view based on an object view.

Example 10–12 Creating an Object View and an XMLType View on the Object View

```
CREATE OR REPLACE VIEW emp_v OF emp_t WITH OBJECT ID (empno) AS
  SELECT emp_t(e.employee_id, e.last_name, e.job_id, e.manager_id, e.hire_date,
               e.salary, e.commission_pct,
               dept_t(d.department_id, d.department_name, d.location_id))
    FROM employees e, departments d
    WHERE e.department_id = d.department_id;

CREATE OR REPLACE VIEW emp_xml OF XMLType
```

```
XMLSCHEMA "http://www.oracle.com/emp_complex.xsd" ELEMENT "Employee"
WITH OBJECT ID DEFAULT AS
SELECT VALUE(p) FROM emp_v p;
```

Creating XMLType Department View, with Nested Employee Information

This section describes how to create `XMLType` view `dept_xml`. Each department in this view contains nested employee information. For the last step, there are two *alternatives*:

- "Step 3a. Create XMLType View dept_xml Using Object Type dept_t" – create `XMLType` view `dept_xml` using the object type for a department, `dept_t`
- "Step 3b. Create XMLType View dept_xml Using Relational Data Directly" – create `XMLType` view `dept_xml` using relational data directly

Step 1. Create Object Types Example 10–13 creates the object types used in the other steps.

Example 10–13 Creating Object Types

```
CREATE TYPE emp_t AS OBJECT (empno    NUMBER(6),
                             ename    VARCHAR2(25),
                             job      VARCHAR2(10),
                             mgr      NUMBER(6),
                             hiredate DATE,
                             sal      NUMBER(8,2),
                             comm     NUMBER(2,2));
/

CREATE OR REPLACE TYPE emplist_t AS TABLE OF emp_t;
/

CREATE TYPE dept_t AS OBJECT (deptno NUMBER(4),
                              dname  VARCHAR2(30),
                              loc    NUMBER(4),
                              emps   emplist_t);
/
```

Step 2. Register XML Schema dept_complex.xsd Create XML schema `dept_complex.xsd`, then register it. Example 10–14 registers it.

Example 10–14 Registering XML Schema dept_complex.xsd

```
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/dept_complex.xsd', 4);
END;
/

BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/dept_complex.xsd',
    SCHEMADOC => '<?xml version="1.0"?>
                  <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                              xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                              xmlns:xdb="http://xmlns.oracle.com/xdb"
                              xsi:schemaLocation="http://xmlns.oracle.com/xdb
                                                  http://xmlns.oracle.com/xdb/XDBSchema.xsd">
                    <xsd:element name="Department" type="DEPT_TType" xdb:SQLType="DEPT_T"/>
                    <xsd:complexType name="DEPT_TType" xdb:SQLType="DEPT_T"
                                     xdb:maintainDOM="false">
```

```
                    <xsd:sequence>
                      <xsd:element name="DEPTNO" type="xsd:double" xdb:SQLName="DEPTNO"
                                   xdb:SQLType="NUMBER"/>
                      <xsd:element name="DNAME" xdb:SQLName="DNAME" xdb:SQLType="VARCHAR2">
                        <xsd:simpleType>
                          <xsd:restriction base="xsd:string">
                            <xsd:maxLength value="30"/>
                          </xsd:restriction>
                        </xsd:simpleType>
                      </xsd:element>
                      <xsd:element name="LOC" type="xsd:double" xdb:SQLName="LOC"
                                   xdb:SQLType="NUMBER"/>
                      <xsd:element name="EMPS" type="EMP_TType" maxOccurs="unbounded"
                                   minOccurs="0" xdb:SQLName="EMPS"
                                   xdb:SQLCollType="EMPLIST_T" xdb:SQLType="EMP_T"
                                   xdb:SQLCollSchema="HR"/>
                    </xsd:sequence>
                  </xsd:complexType>
                  <xsd:complexType name="EMP_TType" xdb:SQLType="EMP_T" xdb:maintainDOM="false">
                    <xsd:sequence>
                      <xsd:element name="EMPNO" type="xsd:double" xdb:SQLName="EMPNO"
                                   xdb:SQLType="NUMBER"/>
                      <xsd:element name="ENAME" xdb:SQLName="ENAME" xdb:SQLType="VARCHAR2">
                        <xsd:simpleType>
                          <xsd:restriction base="xsd:string">
                            <xsd:maxLength value="25"/>
                          </xsd:restriction>
                        </xsd:simpleType>
                      </xsd:element>
                      <xsd:element name="JOB" xdb:SQLName="JOB" xdb:SQLType="VARCHAR2">
                        <xsd:simpleType>
                          <xsd:restriction base="xsd:string">
                            <xsd:maxLength value="10"/>
                          </xsd:restriction>
                        </xsd:simpleType>
                      </xsd:element>
                      <xsd:element name="MGR" type="xsd:double" xdb:SQLName="MGR"
                                   xdb:SQLType="NUMBER"/>
                      <xsd:element name="HIREDATE" type="xsd:date" xdb:SQLName="HIREDATE"
                                   xdb:SQLType="DATE"/>
                      <xsd:element name="SAL" type="xsd:double" xdb:SQLName="SAL"
                                   xdb:SQLType="NUMBER"/>
                      <xsd:element name="COMM" type="xsd:double" xdb:SQLName="COMM"
                                   xdb:SQLType="NUMBER"/>
                    </xsd:sequence>
                  </xsd:complexType>
                </xsd:schema>',
    LOCAL     => TRUE,
    GENTYPES  => FALSE);
END;
/
```

Step 3a. Create XMLType View dept_xml Using Object Type dept_t Example 10–15 creates XMLType view `dept_xml` using object type `dept_t`.

Example 10–15 Creating XMLType View dept_xml Using Object Type dept_t

```
CREATE OR REPLACE VIEW dept_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/dept_complex.xsd" ELEMENT "Department"
  WITH OBJECT ID (XMLCast(XMLQuery('/Department/DEPTNO'
```

```
                                PASSING OBJECT_VALUE RETURNING CONTENT)
                           AS BINARY_DOUBLE)) AS
  SELECT dept_t(d.department_id, d.department_name, d.location_id,
                cast(MULTISET
                     (SELECT emp_t(e.employee_id, e.last_name, e.job_id,
                                   e.manager_id, e.hire_date,
                                   e.salary, e.commission_pct)
                        FROM employees e WHERE e.department_id = d.department_id)
                    AS emplist_t))
    FROM departments d;
```

Step 3b. Create XMLType View dept_xml Using Relational Data Directly Alternatively, you can use SQL/XML publishing functions to create `XMLType` view `dept_xml` from the relational tables without using object type `dept_t`. Example 10–16 illustrates this.

Example 10–16 Creating XMLType View dept_xml Using Relational Data Directly

```
CREATE OR REPLACE VIEW dept_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/dept_complex.xsd" ELEMENT "Department"
  WITH OBJECT ID (XMLCast(XMLQuery('/Department/DEPTNO'
                                PASSING OBJECT_VALUE RETURNING CONTENT)
                           AS BINARY_DOUBLE)) AS
  SELECT
    XMLElement(
      "Department",
      XMLAttributes('http://www.oracle.com/dept_complex.xsd' AS "xmlns",
                    'http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
                    'http://www.oracle.com/dept_complex.xsd
                     http://www.oracle.com/dept_complex.xsd'
                      AS "xsi:schemaLocation"),
      XMLForest(d.department_id "DeptNo", d.department_name "DeptName",
                d.location_id "Location"),
      (SELECT XMLAgg(XMLElement("Employee",
                                XMLForest(e.employee_id "EmployeeId",
                                          e.last_name "Name",
                                          e.job_id "Job",
                                          e.manager_id "Manager",
                                          e.hire_date "Hiredate",
                                          e.salary "Salary",
                                          e.commission_pct "Commission")))
                       FROM employees e WHERE e.department_id = d.department_id))
    FROM departments d;
```

> **Note:** XML schema and element information must be specified at the view level, because the `SELECT` list could arbitrarily construct XML of a different XML schema from the underlying table.

Creating XMLType Views from XMLType Tables

An `XMLType` view can be created on an `XMLType` table, for example, to transform the XML data or to restrict the rows returned.

Example 10–17 creates an `XMLType` view by restricting the rows included from an underlying `XMLType` table. It uses XML schema `dept_complex.xsd` to create the underlying table—see "Creating XMLType Department View, with Nested Employee Information".

Example 10–17 Creating an XMLType View by Restricting Rows from an XMLType Table

```
CREATE TABLE dept_xml_tab OF XMLType
    XMLSchema "http://www.oracle.com/dept_complex.xsd" ELEMENT "Department"
    NESTED TABLE XMLDATA."EMPS" STORE AS dept_xml_tab_tab1;

CREATE OR REPLACE VIEW dallas_dept_view OF XMLType
    XMLSchema "http://www.oracle.com/dept.xsd" ELEMENT "Department"
        AS SELECT OBJECT_VALUE FROM dept_xml_tab
           WHERE XMLCast(XMLQuery('/Department/LOC'
                                  PASSING OBJECT_VALUE RETURNING CONTENT)
                         AS VARCHAR2(20))
                 = 'DALLAS';
```

Here, `dallas_dept_view` restricts the `XMLType` table rows to those departments whose location is Dallas.

Example 10–18 shows how you can create an `XMLType` view by transforming XML data using an XSL stylesheet.

Example 10–18 Creating an XMLType View by Transforming an XMLType Table

```
CREATE OR REPLACE VIEW hr_po_tab OF XMLType
  ELEMENT "PurchaseOrder" WITH OBJECT ID DEFAULT AS
  SELECT XMLtransform(OBJECT_VALUE, x.col1)
    FROM purchaseorder p, xsl_tab x;
```

> **See Also:** "SQL Function XMLTRANSFORM and XMLType Method TRANSFORM()" on page 7-3

Referencing XMLType View Objects Using SQL Function REF

You can reference an `XMLType` view object using SQL function `ref`:

```
SELECT ref(d) FROM dept_xml_tab d;
```

An `XMLType` view reference is based on one of the following object IDs:

- System-generated OID — for views on `XMLType` tables or object views
- Primary key based OID -- for views with `OBJECT ID` expressions

These `REF`s can be used to fetch `OCIXMLType` instances in the OCI Object cache, or they can be used in SQL queries. These `REF`s act the same as `REF`s to object views.

DML (Data Manipulation Language) on XMLType Views

A given `XMLType` view might not be implicitly updatable. In that case you must write instead-of triggers to handle all data manipulation (DML). One way to determine whether a given `XMLType` view is implicitly updatable is to query the view to see whether it is based on an object view or an object constructor that is itself inherently updatable. Example 10–19 illustrates this.

Example 10–19 Determining Whether an XMLType View Is Implicitly Updatable

```
CREATE TYPE dept_t AS OBJECT
      (deptno NUMBER(4),
       dname  VARCHAR2(30),
       loc    NUMBER(4));
/
```

```
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/dept.xsd', 4);
END;
/
COMMIT;

BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/dept_t.xsd',
    SCHEMADOC => '<?xml version="1.0"?>
                  <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                              xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                              xmlns:xdb="http://xmlns.oracle.com/xdb"
                              xsi:schemaLocation="http://xmlns.oracle.com/xdb
                                                  http://xmlns.oracle.com/xdb/XDBSchema.xsd">
                    <xsd:element name="Department" type="DEPT_TType" xdb:SQLType="DEPT_T"/>
                    <xsd:complexType name="DEPT_TType" xdb:SQLType="DEPT_T"
                                     xdb:maintainDOM="false">
                      <xsd:sequence>
                        <xsd:element name="DEPTNO" type="xsd:double" xdb:SQLName="DEPTNO"
                                     xdb:SQLType="NUMBER"/>
                        <xsd:element name="DNAME" xdb:SQLName="DNAME" xdb:SQLType="VARCHAR2">
                          <xsd:simpleType>
                            <xsd:restriction base="xsd:string">
                              <xsd:maxLength value="30"/>
                            </xsd:restriction>
                          </xsd:simpleType>
                        </xsd:element>
                        <xsd:element name="LOC" type="xsd:double" xdb:SQLName="LOC"
                                     xdb:SQLType="NUMBER"/>
                      </xsd:sequence>
                    </xsd:complexType>
                  </xsd:schema>',
    LOCAL     => TRUE,
    GENTYPES  => FALSE);
END;
/

CREATE OR REPLACE VIEW dept_xml of XMLType
  XMLSchema "http://www.oracle.com/dept_t.xsd" element "Department"
  WITH OBJECT ID (XMLCast(XMLQuery('/Department/DEPTNO'
                                   PASSING OBJECT_VALUE RETURNING CONTENT)
                          AS BINARY_DOUBLE)) AS
  SELECT dept_t(d.department_id, d.department_name, d.location_id)
    FROM departments d;

INSERT INTO dept_xml
  VALUES (
    XMLType.createXML(
      '<Department
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:noNamespaceSchemaLocation="http://www.oracle.com/dept_t.xsd" >
         <DEPTNO>300</DEPTNO>
         <DNAME>Processing</DNAME>
         <LOC>1700</LOC>
       </Department>'));

UPDATE dept_xml d
  SET d.OBJECT_VALUE =
```

```
XMLQuery('copy $i := $p1 modify
            (for $j in $i/Department/DNAME
             return replace value of node $j with $p2)
          return $i'
         PASSING d.OBJECT_VALUE AS "p1", 'Shipping' AS "p2" RETURNING CONTENT)
WHERE XMLExists('/Department[DEPTNO=300]' PASSING OBJECT_VALUE);
```

Part IV

XMLType APIs

Part IV of this manual introduces you to ways you can use Oracle XML DB XMLType PL/SQL, Java, C APIs, and Oracle Data Provider for .NET (ODP.NET) to access and manipulate XML data. It contains the following chapters:

11

PL/SQL APIs for XMLType

This chapter describes the use of the APIs for `XMLType` in PL/SQL. It contains these topics:

Overview of PL/SQL APIs for XMLType

This chapter describes the PL/SQL Application Program Interfaces (APIs) for `XMLType`. These include the following:

- PL/SQL Document Object Model (DOM) API for `XMLType` (package `DBMS_XMLDOM`): For accessing `XMLType` objects. You can access both XML schema-based and non-schema-based documents. Before database startup, you must specify the read-from and write-to directories in file `initialization.ORA`. For example:

  ```
  UTL_FILE_DIR=/mypath/insidemypath
  ```

  The read-from and write-to files must be on the server file system.

  A **DOM** is a tree-based object representation of an XML document in dynamic memory. It enables programmatic access to its elements and attributes. The DOM object and its interface is a W3C recommendation. It specifies the Document Object Model of an XML document including APIs for programmatic access. DOM views the parsed document as a tree of objects.
- PL/SQL XML Parser API for `XMLType` (package `DBMS_XMLPARSER`): For creating a DOM and accessing the content and structure of XML documents.
- PL/SQL XSLT Processor for `XMLType` (package `DBMS_XSLPROCESSOR`): For transforming XML documents to other formats using XSLT.

PL/SQL APIs for XMLType: Features

The PL/SQL APIs for `XMLType` allow you to perform the following tasks:

- Create `XMLType` tables, columns, and views
- Construct `XMLType` instances from data encoded in different character sets.
- Access `XMLType` data
- Manipulate `XMLType` data

See Also:

- "Oracle XML DB Features", for an overview of the Oracle XML DB architecture and new features.
- Chapter 5, "Query and Update of XML Data"
- *Oracle Database PL/SQL Packages and Types Reference*

Lazy Loading of XML Data (Lazy Manifestation)

Because `XMLType` provides a dynamic memory or virtual Document Object Model (DOM), it can use a memory conserving process called **lazy XML loading**, also sometimes referred to as **lazy manifestation**. This process optimizes memory usage by only loading rows of data when they are requested. It throws away previously-referenced sections of the document if memory usage grows too large. Lazy XML loading supports highly scalable applications that have many concurrent users needing to access large XML documents.

XMLType Data Type Supports XML Schema

The `XMLType` data type includes support for XML schemas. You can create an XML schema and annotate it with mappings from XML to object-relational storage. To take advantage of the PL/SQL DOM API, first create an XML schema and register it. Then, when you create `XMLType` tables and columns, you can specify that these conform to the registered XML schema.

XMLType Supports Data in Different Character Sets

`XMLType` instances can be created from data encoded in any Oracle-supported character set by using the PL/SQL `XMLType` constructor or `XMLType` method `createXML()`. The source XML data must be supplied using data type `BFILE` or `BLOB`. The encoding of the data is specified through argument `csid`. When this argument is zero (`0`), the encoding of the source data is determined from the XML prolog, as specified in Appendix F of the XML 1.0 Reference.

Caution: *AL32UTF8* is the Oracle Database character set that is appropriate for `XMLType` data. It is equivalent to the IANA registered standard UTF-8 encoding, which supports all valid XML characters.

Do not confuse Oracle Database database character set UTF8 (no hyphen) with database character set AL32UTF8 or with character *encoding* UTF-8. Database character set UTF8 has been *superseded* by AL32UTF8. Do *not* use UTF8 for XML data. Character set UTF8 supports only Unicode version 3.1 and earlier. It does not support all valid XML characters. AL32UTF8 has no such limitation.

Using database character set UTF8 for XML data could potentially *stop a system or affect security negatively*. If a character that is not supported by the database character set appears in an input-document element name, a replacement character (usually "`?`") is substituted for it. This terminates parsing and raises an exception. It could cause an irrecoverable error.

PL/SQL APIs for XMLType: References

Table 11–1 lists the reference documentation for the PL/SQL Application Programming Interfaces (APIs) that you can use to manipulate XML data. The main reference for PL/SQL APIs is *Oracle Database PL/SQL Packages and Types Reference*.

See Also:

- *Oracle Database XML Java API Reference* for information about Java APIs for XML
- *Oracle Database XML C API Reference* for information about C APIs for XML
- *Oracle Database XML C++ API Reference*for information about C++ APIs for XML

Table 11–1 PL/SQL APIs Related to XML

API	Documentation	Description
`XMLType`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "XMLType"	PL/SQL APIs with XML operations on `XMLType` data – validation, transformation.
Database URI types	*Oracle Database PL/SQL Packages and Types Reference*, chapter "Database URI TYPEs"	Functions used for various URI types.
`DBMS_METADATA`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_METADATA"	PL/SQL API for retrieving metadata from the database dictionary as XML, or retrieving creation DDL and submitting the XML to re-create the associated object.
`DBMS_RESCONFIG`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_RESCONFIG"	PL/SQL API to operate on a resource configuration list, and to retrieve listener information for a resource.
`DBMS_XDB_ADMIN`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XDB_ADMIN"	PL/SQL API for the management of Oracle XML DB Repository by database administrators.
`DBMS_XDB_CONFIG`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XDB_CONFIG"	PL/SQL API for managing Oracle XML DB configuration sessions.
`DBMS_XDB_CONSTANTS`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XDB_CONSTANTS"	PL/SQL constants for use with Oracle XML DB
`DBMS_XDB_REPOS`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XDB_REPOS"	PL/SQL API for the use of Oracle XML DB Repository by application developers.
`DBMS_XDBRESOURCE`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XDBRESOURCE"	PL/SQL API to operate on repository resource metadata and contents.
`DBMS_XDBT`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XDBT"	PL/SQL API for creation of text indexes on repository resources.
`DBMS_XDB_VERSION`	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XDB_VERSION"	PL/SQL API for version management of repository resources.

Table 11–1 (Cont.) PL/SQL APIs Related to XML

API	Documentation	Description
DBMS_XDBZ	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XDBZ"	Oracle XML DB Repository ACL-based security.
DBMS_XEVENT	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XEVENT"	PL/SQL API providing event-related types and supporting interface. .
DBMS_XMLDOM	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLDOM"	PL/SQL implementation of the DOM API for XMLType.
DBMS_XMLGEN	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLGEN"	PL/SQL API for transformation of SQL query results into canonical XML format.
DBMS_XMLINDEX	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLINDEX	PL/SQL API for XMLIndex.
DBMS_XMLPARSER	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLPARSER"	PL/SQL implementation of the DOM Parser API for XMLType.
DBMS_XMLSCHEMA	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSCHEMA	PL/SQL API for managing XML schemas within Oracle Database – schema registration, deletion.
DBMS_XMLSCHEMA_ANNOTATE	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSCHEMA_ANNOTATE"	PL/SQL API for adding and managing Oracle-specific XML Schema annotations.
DBMS_XMLSTORAGE_MANAGE	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSTORAGE_MANAGE"	PL/.SQL API managing and modifying storage of XML data after XML schema registration.
DBMS_XMLSTORE	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSTORE"	PL/SQL API for storing XML data in relational tables.
DBMS_XSLPROCESSOR	*Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XSLPROCESSOR"	PL/SQL implementation of an XSLT processor.

PL/SQL DOM API for XMLType (DBMS_XMLDOM)

This section describes the PL/SQL DOM API for XMLType, DBMS_XMLDOM.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for descriptions of the individual DBMS_XMLDOM methods

Overview of the W3C Document Object Model (DOM) Recommendation

Skip this section if you are familiar with the generic DOM specifications recommended by the World Wide Web Consortium (W3C).

The Document Object Model (DOM) recommended by the W3C is a universal API for accessing the structure of XML documents. It was originally developed to formalize Dynamic HTML, which is used for animation, interaction, and dynamic updating of Web pages. DOM provides a language-neutral and platform-neutral object model for Web pages and XML documents. DOM describes language-independent and platform-independent interfaces to access and operate on XML components and

elements. It expresses the structure of an XML document in a universal, content-neutral way. Applications can be written to dynamically delete, add, and edit the content, attributes, and style of XML documents. DOM makes it possible to create applications that work properly on all browsers, servers, and platforms.

Oracle XML Developer's Kit Extensions to the W3C DOM Standard

Oracle XML Developer's Kit (XDK) extends the W3C DOM API in various ways. All of these extensions are supported by Oracle XML DB except those relating to client-side operations that are not applicable in the database. This type of procedural processing is available through the Simple API for XML (SAX) interface in the Oracle XML Developer's Kit Java and C components.

See Also: *Oracle XML Developer's Kit Programmer's Guide*

Supported W3C DOM Recommendations

All Oracle XML DB APIs for accessing and manipulating XML comply with standard XML processing requirements as approved by the W3C. The PL/SQL DOM supports Levels 1 and 2 from the W3C DOM specifications.

- In Oracle9*i* release 1 (9.0.1), Oracle XML Developer's Kit for PL/SQL implemented DOM Level 1.0 and parts of DOM Level 2.0.
- In Oracle9*i* release 2 (9.2) and Oracle Database 10*g* release 1 (10.1), the PL/SQL API for `XMLType` implements DOM Levels 1.0 and Level 2.0 Core, and is fully integrated in the database through extensions to the `XMLType` API.

The following briefly describes each level:

- **DOM Level 1.0 –** The first formal Level of the DOM specifications, completed in October 1998. Level 1.0 defines support for XML 1.0 and HTML.
- **DOM Level 2.0 –** Completed in November 2000, Level 2.0 extends Level 1.0 with support for XML 1.0 with namespaces and adds support for Cascading Style Sheets (CSS) and events (user-interface events and tree manipulation events), and enhances tree manipulations (tree ranges and traversal mechanisms). CSS are a simple mechanism for adding style (fonts, colors, spacing, and so on) to Web documents.

Difference Between DOM and SAX

The generic APIs for XML can be classified in two main categories:

- Tree-based. DOM is the primary generic tree-based API for XML.
- Event-based. SAX (Simple API for XML) is the primary generic event-based programming interface between an XML parser and an XML application.

DOM works by creating objects. These objects have child objects and properties, and the child objects have child objects and properties, and so on. Objects are referenced either by moving down the object hierarchy or by explicitly giving an HTML element an ID attribute. For example:

```
<img src="employee_jdoe.gif" ID="0123jdoe">
```

Examples of structural manipulations are:

- Reordering elements
- Adding or deleting elements
- Adding or deleting attributes

- Renaming elements

See Also:

- http://www.w3.org/DOM/ for information about DOM
- http://www.saxproject.org/ for information about SAX

PL/SQL DOM API for XMLType (DBMS_XMLDOM): Features

Oracle XML DB extends the Oracle Database XML development platform beyond SQL support for storage and retrieval of XML data. It lets you operate on XMLType instances using DOM in PL/SQL, Java, and C.

The *default* action for the PL/SQL DOM API for XMLType (DBMS_XMLDOM) is to do the following:

- Produce a parse tree that can be accessed by DOM APIs.
- Validate, if a DTD is found. Otherwise, do not validate.
- Raise an application error if parsing fails.

DTD validation occurs when the object document is manifested. If lazy manifestation is employed, then the document is validated when it is used.

The PL/SQL DOM API exploits a C-based representation of XML in the server and operates on XML schema-based XML instances. The PL/SQL, Java, and C DOM APIs for XMLType comply with the W3C DOM Recommendations to define and implement object-relational storage of XML data in relational or object-relational columns and as dynamic memory instances of XMLType. See "Preparing XML Data to Use the PL/SQL DOM API for XMLType" on page 11-7, for a description of W3C DOM Recommendations.

XML Schema Support

The PL/SQL DOM API for XMLType supports XML schema. Oracle XML DB uses annotations within an XML schema as metadata to determine the structure of an XML document and the mapping of the document to a database schema.

Note: For backward compatibility and flexibility, the PL/SQL DOM supports both XML schema-based documents and non-schema-based documents.

After an XML schema is registered with Oracle XML DB, the PL/SQL DOM API for XMLType builds a tree representation of an associated XML document in dynamic memory as a hierarchy of node objects, each with its own specialized interfaces. Most node object types can have child node types, which in turn implement additional, more specialized interfaces. Nodes of some node types can have child nodes of various types, while nodes of other node types must be leaf nodes, which do not have child nodes.

Enhanced Performance

Oracle XML DB uses DOM to provide a standard way to translate data between XML and multiple back-end data sources. This eliminates the need to use separate XML translation techniques for the different data sources in your environment. Applications needing to exchange XML data can use a single native XML database to cache XML documents. Oracle XML DB can thus speed up application performance by acting as

an intermediate cache between your Web applications and your back-end data sources, whether they are in relational databases or file systems.

See Also: Chapter 13, "Java DOM API for XMLType"

Application Design Using Oracle XML Developer's Kit and Oracle XML DB

When you build applications based on Oracle XML DB, you do not need the additional components in Oracle XML Developer's Kit. However, you can use Oracle XML Developer's Kit components with Oracle XML DB to deploy a full suite of XML-enabled applications that run end-to-end. You can use features in Oracle XML Developer's Kit for:

- Simple API for XML (SAX) interface processing. SAX is an XML standard interface provided by XML parsers and used by procedural and event-based applications.
- DOM interface processing, for structural and recursive object-based processing.

Oracle XML Developer's Kit contain the basic building blocks for creating applications that run on a client, in a browser or a plug-in. Such applications typically read, manipulate, transform and view XML documents. To provide a broad variety of deployment options, Oracle XML Developer's Kit is available for Java, C, and C++. Oracle XML Developer's Kit is fully supported and comes with a commercial redistribution license.

Oracle XML Developer's Kit for Java consists of these components:

- **XML Parsers –** Creates and parses XML using industry standard DOM and SAX interfaces. Supports Java, C, C++, and the Java API for XML Processing (JAXP).
- **XSL Processor –** Transforms or renders XML into other text-based formats such as HTML. Supports Java, C, and C++.
- **XML Schema Processor –** Uses XML simple and complex data types. Supports Java, C, and C++.
- **XML Class Generator, Oracle JAXB Class Generator –** Automatically generate C++ and Java classes, respectively, from DTDs and XML schemas, to send XML data from Web forms or applications. Class generators accept an input file and create a set of output classes that have corresponding functionality. For the XML Class Generator, the input file is a DTD, and the output is a series of classes that can be used to create XML documents conforming with the DTD.
- **XML SQL Utility –** Generates XML documents, DTDs, and XML schemas from SQL queries. Supports Java.
- **TransX Utility –** Loads data encapsulated in XML into the database. Has additional functionality useful for installations.
- **XML Pipeline Processor –** Invokes Java processes through XML control files.
- **XSLT VM and Compiler –** Provides a high-performance C-based XSLT transformation engine that uses compiled XSL stylesheets.
- **XML Java Beans –** Parses, transforms, compares, retrieves, and compresses XML documents using Java components.

See Also: *Oracle XML Developer's Kit Programmer's Guide*

Preparing XML Data to Use the PL/SQL DOM API for XMLType

To prepare data for using PL/SQL DOM APIs in Oracle XML DB:

1. Create a standard XML schema.
2. Annotate the XML schema with definitions for the SQL objects you use.
3. Register the XML schema, to generate the necessary database mappings.

You can then do any of the following:

- Use `XMLType` views to wrap existing relational or object-relational data in XML formats, making it available to your applications in XML form. See "Wrap Existing Data as XML with XMLType Views" on page 11-9.
- Insert XML data into `XMLType` columns.
- Use Oracle XML DB PL/SQL and Java DOM APIs to manipulate XML data stored in `XMLType` columns and tables.

XML Schema Types Are Mapped to SQL Object Types

An XML schema must be registered before it can be referenced by an XML document. When you register an XML schema, elements and attributes it declares are mapped to attributes of corresponding SQL object types within the database.

After XML schema registration, XML documents that conform to the XML schema and reference it can be managed by Oracle XML DB. Tables and columns for storing the conforming documents can be created for root elements defined by the XML schema.

> **See Also:** Chapter 17, "XML Schema Storage and Query: Basic"

An XML schema is registered by using PL/SQL package `DBMS_XMLSCHEMA` and by specifying the schema document and its *schema-location URL*. This URL is a name that uniquely identifies the registered schema within the database. It need not correspond to any real location—in particular, it need not indicate where the schema document is located.

The *target namespace* of the schema is another URL used in the XML schema. It specifies a namespace for the XML-schema elements and types. An XML document should specify both the namespace of the root element and the schema-location URL identifying the schema that defines this element.

When documents are inserted into Oracle XML DB using path-based protocols such as HTTP(S) and FTP, the XML schema to which the document conforms is *registered implicitly*, provided its name and location are specified and it has not yet been registered.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* descriptions of the individual `DBMS_XMLSCHEMA` methods

DOM Fidelity for XML Schema Mapping

Elements and attributes declared within an XML schema get mapped to separate attributes of the corresponding SQL object type. Other information encoded in an XML document, such as comments, processing instructions, namespace declarations and prefix definitions, and whitespace, is not represented directly.

To store this additional information, binary attribute `SYS_XDBPD$` is present in all generated SQL object types. This database attribute stores all information in the original XML document that is not stored using the other database attributes. Retaining this accessory information ensures *DOM fidelity* for XML documents stored in Oracle XML DB: an XML document retrieved from the database is identical to the original document that was stored.

Note: In this book, attribute SYS_XDBPD$ has been omitted from most examples, for simplicity. However, the attribute is always present in SQL object types generated by schema registration.

See Also: "SYS_XDBPD$ and DOM Fidelity for Object-Relational Storage" on page 18-5

Wrap Existing Data as XML with XMLType Views

To make existing relational and object-relational data available to your XML applications, you can create XMLType views, wrapping the data in an XML format. You can then access this XML data using the PL/SQL DOM API.

After you register an XML schema containing annotations that represent the mapping between XML types and SQL object types, you can create an XMLType view that conforms to the XML schema.

See Also: Chapter 10, "XMLType Views"

DBMS_XMLDOM Methods Supported by Oracle XML DB

All DBMS_XMLDOM methods are supported by Oracle XML DB, with the *exception* of the following:

- writeExternalDTDToFile()
- writeExternalDTDToBuffer()
- writeExternalDTDToClob()

See Also: *Oracle Database PL/SQL Packages and Types Reference* for descriptions of the individual DBMS_XMLDOM methods

PL/SQL DOM API for XMLType: Node Types

In the DOM specification, the term "**document**" is used to describe a container for many different kinds of information or data, which the DOM objectifies. The DOM specifies the way elements within an XML document container are used to create an object-based tree structure and to define and expose interfaces to manage and use the objects stored in XML documents. Additionally, the DOM supports storage of documents in diverse systems.

When a request such as getNodeType(myNode) is given, it returns myNodeType, which is the node type supported by the parent node. These constants represent the different types that a node can adopt:

- ELEMENT_NODE
- ATTRIBUTE_NODE
- TEXT_NODE
- CDATA_SECTION_NODE
- ENTITY_REFERENCE_NODE
- ENTITY_NODE
- PROCESSING_INSTRUCTION_NODE
- COMMENT_NODE

- DOCUMENT_NODE
- DOCUMENT_TYPE_NODE
- DOCUMENT_FRAGMENT_NODE
- NOTATION_NODE

Table 11–2 shows the node types for XML and HTML and the allowed corresponding children node types.

Table 11–2 XML and HTML DOM Node Types and Their Child Node Types

Node Type	Children Node Types
Document	Element (maximum of one), ProcessingInstruction, Comment, DocumentType (maximum of one)
DocumentFragment	Element, ProcessingInstruction, Comment, Text, CDATASection, EntityReference
DocumentType	No children
EntityReference	Element, ProcessingInstruction, Comment, Text, CDATASection, EntityReference
Element	Element, Text, Comment, ProcessingInstruction, CDATASection, EntityReference
Attr	Text, EntityReference
ProcessingInstruction	No children
Comment	No children
Text	No children
CDATASection	No children
Entity	Element, ProcessingInstruction, Comment, Text, CDATASection, EntityReference
Notation	No children

Oracle XML DB DOM API for XMLType also specifies these interfaces:

- **A NodeList interface** to handle ordered lists of Nodes, for example:
  - The children of a Node
  - Elements returned by method getElementsByTagName() of the element interface
- **A NamedNodeMap interface** to handle unordered sets of nodes, referenced by their name attribute, such as the attributes of an element.

PL/SQL Function NEWDOMDOCUMENT and DOMDOCUMENT Nodes

PL/SQL function newDOMDocument constructs a DOM document handle, given an XMLType value.

A typical usage scenario for a PL/SQL application is:

1. Fetch or construct an XMLType instance
2. Construct a DOMDocument node over the XMLType instance
3. Use the DOM API to access and manipulate the XML data

Note: For DOMDocument, node types represent handles to XML fragments but do not represent the data itself.

For example, if you copy a node value, DOMDocument clones the handle to the same underlying data. Any data modified by one of the handles is visible when accessed by the other handle. The XMLType value from which the DOMDocument handle is constructed is the data, and reflects the results of all DOM operations on it.

DOM NodeList and NamedNodeMap Objects

Changes to the underlying document structure are reflected in all relevant NodeList and NamedNodeMap objects.

For example, if a DOM user gets a NodeList object containing the children of an element, and then subsequently adds more children to that element (or removes children, or modifies them), then those changes are automatically propagated in the NodeList, without additional action from the user. Likewise, changes to a node in the tree are propagated throughout all references to that node in NodeList and NamedNodeMap objects.

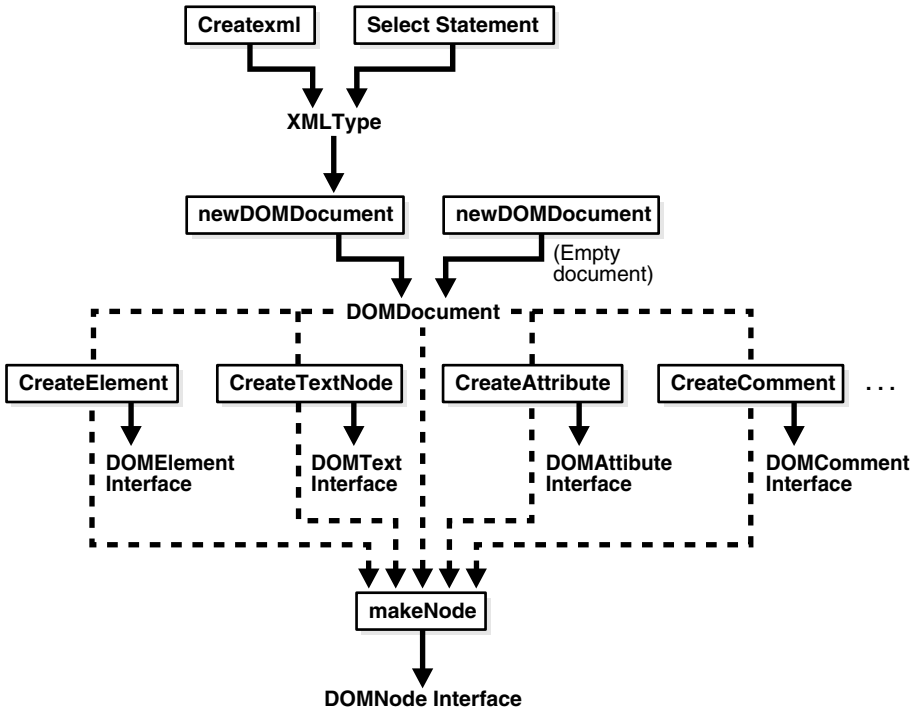
The interfaces: Text, Comment, and CDATASection, all inherit from the CharacterData interface.

Using the PL/SQL DOM API for XMLType (DBMS_XMLDOM)

Figure 11–1 illustrates the use of PL/SQL DOM API for XMLType (DBMS_XMLDOM).

1. You can create a DOM document (DOMDocument) from an existing XMLType or as an empty document.
2. Procedure newDOMDocument processes the XMLType instance or empty document. This creates a DOMDocument instance.
3. You can use DOM API PL/SQL methods such as createElement(), createText(), createAttribute(), and createComment() to traverse and extend the DOM tree.
4. The results of PL/SQL methods such as DOMElement() and DOMText() can also be passed to PL/SQL function makeNode to obtain the DOMNode interface.

Figure 11–1 Using the PL/SQL DOM API for XMLType



PL/SQL DOM API for XMLType – Examples

This section presents examples of using the PL/SQL DOM API for `XMLType`.

Remember to call procedure `freeDocument` for *each* `DOMDocument` instance, when you are through with the instance. This procedure frees the document and all of its nodes. You can still access `XMLType` instances on which `DOMDocument` instances were built, even after the `DOMDocument` instances have been freed.

Example 11–1 creates a hierarchical, representation of an XML document in dynamic memory: a DOM document.

Example 11–1 Creating and Manipulating a DOM Document

```
CREATE TABLE person OF XMLType;

DECLARE
  var       XMLType;
  doc       DBMS_XMLDOM.DOMDocument;
  ndoc      DBMS_XMLDOM.DOMNode;
  docelem   DBMS_XMLDOM.DOMElement;
  node      DBMS_XMLDOM.DOMNode;
  childnode DBMS_XMLDOM.DOMNode;
  nodelist  DBMS_XMLDOM.DOMNodelist;
  buf       VARCHAR2(2000);
BEGIN
  var := XMLType('<PERSON><NAME>ramesh</NAME></PERSON>');

  -- Create DOMDocument handle
  doc     := DBMS_XMLDOM.newDOMDocument(var);
  ndoc    := DBMS_XMLDOM.makeNode(doc);

  DBMS_XMLDOM.writeToBuffer(ndoc, buf);
```

```
  DBMS_OUTPUT.put_line('Before:'||buf);

  docelem := DBMS_XMLDOM.getDocumentElement(doc);

  -- Access element
  nodelist := DBMS_XMLDOM.getElementsByTagName(docelem, 'NAME');
  node := DBMS_XMLDOM.item(nodelist, 0);
  childnode := DBMS_XMLDOM.getFirstChild(node);

  -- Manipulate element
  DBMS_XMLDOM.setNodeValue(childnode, 'raj');
  DBMS_XMLDOM.writeToBuffer(ndoc, buf);
  DBMS_OUTPUT.put_line('After:'||buf);
  DBMS_XMLDOM.freeDocument(doc);
  INSERT INTO person VALUES (var);
END;
/
```

This produces the following output:

```
Before:<PERSON>
  <NAME>ramesh</NAME>
</PERSON>

After:<PERSON>
  <NAME>raj</NAME>
</PERSON>
```

This query confirms that the data has changed:

```
SELECT * FROM person;
SYS_NC_ROWINFO$
---------------
<PERSON>
  <NAME>raj</NAME>
</PERSON>

1 row selected.
```

Example 11–1 uses a *handle* to the DOM document to manipulate it: print it, change part of it, and print it again after the change. Manipulating the DOM document by its handle also indirectly affects the XML data represented by the document, so that querying that data after the change shows the changed result.

The DOM document is created from an `XMLType` variable using PL/SQL function `newDOMDocument`. The handle to this document is created using function `makeNode`. The document is written to a `VARCHAR2` buffer using function `writeToBuffer`, and the buffer is printed using `DBMS_OUTPUT.put_line`.

After manipulating the document using various `DBMS_XMLDOM` procedures, the (changed) data in the `XMLType` variable is inserted into a table and queried, showing the change. It is only when the data is inserted into a database table that it becomes persistent. Until then, it exists in memory only. This persistence is demonstrated by the fact that the database query is made after the document (`DOMDocument` instance) has been freed from dynamic memory.

Example 11–2 creates an empty DOM document, and then adds an element node (`<ELEM>`) to the document. `DBMS_XMLDOM` API node procedures are used to obtain the name (`<ELEM>`), value (`NULL`), and type (`1` = element node) of the element node.

Example 11–2 Creating an Element Node and Obtaining Information About It

```
DECLARE
  doc   DBMS_XMLDOM.DOMDocument;
  elem  DBMS_XMLDOM.DOMElement;
  nelem DBMS_XMLDOM.DOMNode;
BEGIN
  doc := DBMS_XMLDOM.newDOMDocument;
  elem := DBMS_XMLDOM.createElement(doc, 'ELEM');
  nelem := DBMS_XMLDOM.makeNode(elem);
  DBMS_OUTPUT.put_line('Node name = ' || DBMS_XMLDOM.getNodeName(nelem));
  DBMS_OUTPUT.put_line('Node value = '|| DBMS_XMLDOM.getNodeValue(nelem));
  DBMS_OUTPUT.put_line('Node type = ' || DBMS_XMLDOM.getNodeType(nelem));
  DBMS_XMLDOM.freeDocument(doc);
END;
/
```

This produces the following output:

```
Node name = ELEM
Node value =
Node type = 1
```

Large Node Handling Using DBMS_XMLDOM

Prior to Oracle Database 11g Release 1 (11.1), each text node or attribute value processed by Oracle XML DB was limited in size to 64 K bytes. Starting with release 11.1, this restriction no longer applies.

To overcome this size limitation and allow nodes to contain graphics files, PDF files, and multibyte character encodings, the following abstract streams are available. These abstract PL/SQL streams are analogous to the corresponding Java streams. Each input stream has an associated writer, or data producer, and each output stream has an associated reader, or data consumer.

1. **Binary Input Stream:** This provides the data consumer with read-only access to source data, as a sequential (non-array) linear space of bytes. The consumer has iterative read access to underlying source data (whatever representation) in binary format, that is, read access to source data in unconverted, "raw" format. The consumer sees a sequence of bytes as they exist in the node. There is no specification of the format or representation of the source data. In particular, there is no associated character set.
2. **Binary Output Stream:** This provides the data producer with write-only access to target data as a sequential (non-array) linear space of bytes. The producer has iterative write access to target data in binary format, that is, write access to target data in pure binary format with no data semantics at all. The producer passes a sequence of bytes and the target data is replaced by these bytes. No data conversion occurs.
3. **Character Input Stream:** This provides the data consumer iterative read-only access to source data as a sequential (non-array) linear space of characters, independent of the representation and format of the source data. Conversion of the source data may or may not occur.
4. **Character Output Stream:** This provides the data producer with iterative write-only access to target data as a sequential (non-array) linear space of characters. The producer passes a sequence of characters and the target data is replaced by this sequence of characters. Conversion of the passed data may or may not occur.

Each of the input streams has the following abstract methods: open, read, and close. Each of the output streams has the following abstract methods: open, write, flush, and close. For output streams, you must close the stream before any nodes are physically written.

There are four general node access models, for reading and writing. Each access model has both binary and character versions. Binary and character stream methods defined on data type `DOMNode` realize these access models. Each access model is described in a separate section, with an explanation of the PL/SQL functions and procedures in package `DBMS_XMLDOM` that operate on large nodes.

- Get-Push Model
- Get-Pull Model
- Set-Pull Model
- Set-Push Model

For all except the get-push and set-pull access models (whether binary or character), Oracle supplies a concrete stream that you can use (implicitly). For get-push and set-pull, you must define a subtype of the abstract stream type that Oracle provides, and you must implement its access methods (open, close, and so on). For get-push and set-pull, you then instantiate your stream type and supply your stream as an argument to the access method. So, for example, you would use `my_node.getNodeValueAsCharacterStream(my-stream)` for get-push, but just `my_node.getNodeValueAsCharacterStream()` for get-pull. The latter requires no explicit stream argument, because the concrete stream supplied by Oracle is used.

Note: When you access a character-data stream, the access method you use determines the apparent character set of the nodes accessed. If you use Java to access the stream, then the character set seen by your Java program is UCS2 (or an application-specified character set). If you use PL/SQL to access the stream, then the character set seen by your PL/SQL program is the database-session character set (or an application-specified character set). In all cases, however, the XML data is stored in the database in the database character set.

In the following descriptions, C1 is the character set of the node as stored in the database, and C2 is the character set of the node as seen by your program.

See Also:

- "Large XML Node Handling with Java" on page 13-17 for information on using Java with large nodes
- *Oracle Database PL/SQL Packages and Types Reference*
- *Oracle Database XML Java API Reference* for information about Java functions for handling large nodes
- *Oracle Database XML C API Reference* for information about C functions for handling large nodes

Get-Push Model

To read a node value in this model, the application creates a binary output stream or character output stream and passes this to Oracle XML DB. In this case, the source data is the node value. Oracle XML DB populates the output stream by pushing node data into the stream. If the stream is a character output stream, then the character set, C2, is the session character set, and node data is converted, if necessary, from C1 to C2. Additionally, the data type of the node may be any supported by Oracle XML DB and, if the node data type is not character data then the node data is first converted to character data in C2. If a binary output stream, the data type of the node must be `RAW` or `BLOB`.

The procedures of the `DBMS_XMLDOM` package to be used for this case are:

```
PROCEDURE getNodeValueAsBinaryStream (n     IN DBMS_XMLDOM.domnode,
                                      value IN SYS.utl_BinaryOutputStream);
```

The application passes an implementation of `SYS.utl_BinaryOutputStream` into which Oracle XML DB writes the contents of the node. The data type of the node must be `RAW` or `CLOB` or else an exception is raised.

```
PROCEDURE getNodeValueAsCharacterStream (n     IN DBMS_XMLDOM.domnode,
                                         value IN SYS.utl_CharacterOutputStream);
```

The node data is converted, as necessary, to the session character set and then "pushed" into the `SYS.utl_CharacterOutputStream`.

The following example fragments illustrate reading the node value as binary data and driving the write methods in a user-defined subtype of `SYS.utl_BinaryOutPutStream`, which is called `MyBinaryOutputStream`:

Example 11–3 Creating a User-Defined Subtype of SYS.util_BinaryOutputStream()

```
CREATE TYPE MyBinaryOutputStream UNDER SYS.utl_BinaryOutputStream (
    CONSTRUCTOR FUNCTION MyBinaryOutputStream ()
    RETURN SELF AS RESULT,
    MEMBER FUNCTION  write (bytes IN RAW) RETURN INTEGER,
    MEMBER PROCEDURE write (bytes IN RAW, offset IN INTEGER, length IN OUT
           INTEGER),
    MEMBER FUNCTION flush () RETURN BOOLEAN,
    MEMBER FUNCTION close () RETURN BOOLEAN);
);

-- Put code here that implements these methods
...
```

Example 11–4 Retrieving Node Value with a User-Defined Stream

```
DECLARE
  ostream     MyBinaryOutputStream = MyBinaryOutputStream ();
  node        DBMS_XMLDOM.domnode;
  ...
BEGIN
  ...
  -- This drives the write methods in MyBinaryOutputStream,
  -- flushes the data, and closes the stream after the value has been
  -- completely written.
  DBMS_XMLDOM.getNodeValueAsBinaryStream (node, ostream);
  ...
END;
```

Get-Pull Model

To read the value of a node in this model, Oracle XML DB creates a binary input stream or character input stream and returns this to the caller. The character set, C2, of the character input stream is the current session character set. Oracle XML DB populates the input stream as the caller pulls the node data from the stream so Oracle XML DB is again the producer of the data. If the stream is a character input stream, then the node data type may be any supported by Oracle XML DB and node data, if character, is converted, if necessary, from C1 to C2. If the node data is non-character, it is converted to character in C2. If a binary input stream, the data type of the node must be `RAW` or `BLOB`.

The functions of the `DBMS_XMLDOM` package to be used for this case are `getNodeValueAsBinaryStream` and `getNodeValueAsCharacterStream`.

```
FUNCTION getNodeValueAsBinaryStream(n IN DBMS_XMLDOM.domnode)
         RETURN SYS.utl_BinaryInputStream;
```

This function returns an instance of the new PL/SQL `SYS.utl_BinaryInputStream` that can be read using defined methods as described in the section "Set-Pull Model" on page 11-18. The node data type must be `RAW` or `BLOB` or else an exception is raised.

```
FUNCTION getNodeValueAsCharacterStream (n IN DBMS_XMLDOM.domnode)
         RETURN SYS.utl_CharacterInputStream;
```

This function returns an instance of the new PL/SQL `SYS.utl_CharacterInputStream` that can be read using defined methods. If the node data is character it is converted to the current session character set. If the node data is not character data, it is first converted to character data.

Example 11–5 illustrates reading a node value as binary data in 50-byte increments:

Example 11–5 Get-Pull of Binary Data

```
DECLARE
  istream      SYS.utl_BinaryInputStream;
  node         DBMS_XMLDOM.domnode;
  buffer       raw(50);
  numBytes     pls_integer;
  ...
BEGIN
  ...
  istream := DBMS_XMLDOM.getNodeValueAsBinaryStream (node);
  -- Read stream in 50-byte chunks
  LOOP
    numBytes := 50;
    istream.read ( buffer, numBytes);
    if numBytes <= 0 then
       exit;
    end if;
-- Process next 50 bytes of node value in buffer
END LOOP
...
END;
```

Example 11–6 illustrates reading a node value as character data in 50-character increments:

Example 11–6 Get-Pull of Character Data

```
DECLARE
  istream      SYS.utl_CharacterInputStream;
  node         DBMS_XMLDOM.domnode;
  buffer       varchar2(50);
  numChars     pls_integer;
  ...
BEGIN
  ...
  istream := DBMS_XMLDOM.getNodeValueAsCharacterStream (node);
-- Read stream in 50-character chunks
LOOP
   numChars := 50;
   istream.read ( buffer, numChars);
   IF numChars <= 0 then
      exit;
   END IF;
-- Process next 50 characters of node value in buffer
END LOOP
...
END;
```

Set-Pull Model

To write a node value in this mode, the application creates a binary input stream or character input stream and passes this to Oracle XML DB. The character set of the character input stream, C2, is the session character set. Oracle XML DB pulls the data from the input stream and populates the node. If the stream is a character input stream, then the data type of the node may be any supported by Oracle XML DB. If the data type of the node is not character, the stream data is first converted to the node data type. If the node data type is character, then no conversion occurs, so the node data remains in character set C2. If the stream is a `binary input stream`, then the data type of the node must be `RAW` or `BLOB` and no conversion occurs.

The procedures of the `DBMS_XMLDOM` package to be used for this case are `setNodeValueAsBinaryStream` and `setNodeValueAsCharacterStream`.

```
PROCEDURE setNodeValueAsBinaryStream(n IN DBMS_XMLDOM.domnode,
          value IN SYS.utl_BinaryInputStream);
```

The application passes in an implementation of `SYS.utl_BinaryInputStream` from which Oracle XML DB reads data to populate the node. The data type of the node must be `RAW` or `BLOB` or else an exception is raised.

```
PROCEDURE setNodeValueAsCharacterStream (n IN DBMS_XMLDOM.domnode,
          value IN SYS.utl_CharacterInputStream);
```

The application passes in an implementation of `SYS.utl_CharacterInputStream` from which Oracle XML DB reads to populate the node. The data type of the node may be any valid type supported by Oracle XML DB. If it is a non-character data type, the character data read from the stream is converted to the data type of the node. If the data type of the node is either character or `CLOB`, then no conversion occurs and the character set of the node becomes the character set of the PL/SQL session.

Example 11–7 illustrates setting the node value to binary data produced by the read methods defined in a user-defined subtype of `SYS.utl_BinaryInputStream`, which is called `MyBinaryInputStream`:

Example 11–7 Set-Pull of Binary Data

```
CREATE TYPE MyBinaryInputStream UNDER SYS.utl_BinaryInputStream (
    CONSTRUCTOR FUNCTION MyBinaryInputStream ()
    RETURN SELF AS RESULT,
  MEMBER FUNCTION read () RETURN RAW,
  MEMBER PROCEDURE read (bytes IN OUT RAW, numbytes IN OUT INTEGER),
  MEMBER PROCEDURE read (bytes IN OUT RAW,
                         offset IN INTEGER,
                         length IN OUT INTEGER),
  MEMBER FUNCTION close () RETURN BOOLEAN);
```

You can use an object of type `MyBinaryInputStream` to set the value of a node as follows:

```
DECLARE
  istream     MyBinaryInputStream = MyBinaryInputStream ();
  node        DBMS_XMLDOM.domnode;
  ...
BEGIN
  ...
  -- This drives the read methods in MyBinaryInputStream
  DBMS_XMLDOM.setNodeValueAsBinaryStream (node, istream);
  ...
END;
```

Set-Push Model

To write a new node value in this mode, Oracle XML DB creates a binary output stream or character output stream and returns this to the caller. The character set of the character output stream, C2, is the current session character set. The caller pushes data into the output stream and Oracle XML DB then writes this to the Oracle XML DB Node. If the stream is a character output stream, then the data type of the node may be any type supported by Oracle XML DB. In this case, the character data is converted to the node data type. If the node data type is character, then the character set, C1, is changed to C2. No data conversion occurs. If the stream is a binary input stream, and the data type of the node must be `RAW` or `BLOB`. In this case, the stream is read without data conversion.

The procedures of the `DBMS_XMLDOM` package to be used for this case are `setNodeValueAsBinaryStream` and `setNodeValueAsCharacterStream`.

```
FUNCTION setNodeValueAsBinaryStream(n IN DBMS_XMLDOM.domnode)
         RETURN SYS.utl_BinaryOutputStream;
```

This function returns an instance of `SYS.utl_BinaryOutputStream` into which the caller can write the node value. The data type of the node must be `RAW` or `BLOB` or else an exception is raised.

```
FUNCTION setNodeValueAsCharacterStream (n IN DBMS_XMLDOM.domnode)
         RETURN SYS.utl_CharacterOutputStream;
```

This function returns an instance of the PL/SQL `SYS.utl_CharacterOutputStream` type into which the caller can write the node value. The data type of the node can be any valid Oracle XML DB data type. If the type is not character or `CLOB`, the character data written to the stream is converted to the node data type. If the data type of the node is character or `CLOB`, then the character data written to the stream is converted from PL/SQL session character set to the character set of the node

Example 11–8 illustrates setting the value of a node to binary data by writing 50-byte segments into the `SYS.utl_BinaryOutputStream`:

Example 11–8 Set-Push of Binary Data

```
DECLARE
  ostream      SYS.utl_BinaryOutputStream;
  node         DBMS_XMLDOM.domnode;
  buffer       raw(500);
  segment      raw(50);
  numBytes     pls_integer;
  offset       pls_integer;
  ...
BEGIN
  ...
  ostream := DBMS_XMLDOM.setNodeValueAsBinaryStream (node);
  offset := 0;
  length := 500;
  -- Write to stream in 50-byte chunks
  LOOP
    numBytes := 50;
    -- Get next 50 bytes of buffer
    ostream.write ( segment, offset, numBytes);
    length := length - numBytes;
    IF length  <= 0 then
       exit;
    END IF;
  END LOOP
  ostream.close();
  ...
END;
```

Determining Binary Stream or Character Stream

To determine whether to use a character stream or a binary stream to access the node value use the following method which is also included as part of the `DBMS_XMLDOM` package:

```
FUNCTION useBinaryStream (n IN DBMS_XMLDOM.domnode) RETURN BOOLEAN;
```

This function returns `TRUE` if the data type of the node is `RAW` or `BLOB`, so that the node value may be read or written using either a `SYS.utl_BinaryInputStream` or a `SYS.utl_BinaryOutputStream`. If a value of `FALSE` is returned, the node value can be accessed only using a `SYS.utl_CharacterInputStream` or a `SYS.utl_CharacterOutputStream`.

PL/SQL Parser API for XMLType (DBMS_XMLPARSER)

XML documents are made up of storage units, called *entities*, that contain either parsed or unparsed data. Parsed data is made up of characters, some of which form character data and some of which form markup. Markup encodes a description of the document storage layout and logical structure. XML provides a mechanism for imposing constraints on the storage layout and logical structure.

A software module called an XML parser or processor reads XML documents and provides access to their content and structure. An XML parser usually does its work on behalf of another module, typically the application.

Features of the PL/SQL Parser API for XMLType

The PL/SQL Parser API for `XMLType` (`DBMS_XMLPARSER`) builds a result tree that can be accessed by PL/SQL APIs. If parsing fails, it raises an error.

Method DBMS_XMLPARSER.setErrorLog() is not supported.

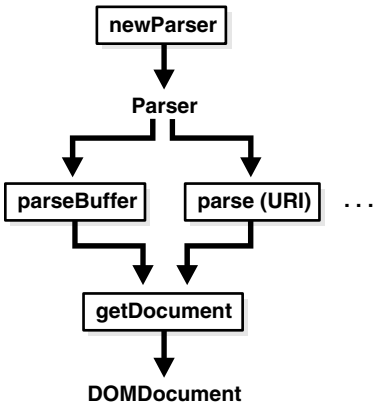
> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for descriptions of individual DBMS_XMLPARSER methods

Using the PL/SQL Parser API for XMLType (DBMS_XMLPARSER)

Figure 11–2 illustrates how to use the PL/SQL Parser for XMLType (DBMS_XMLPARSER). These are the steps:

1. Construct a parser instance using PL/SQL method newParser().
2. Parse XML documents using PL/SQL methods such as parseBuffer(), parseClob(), and parse(URI). An error is raised if the input is not a valid XML document.
3. Call PL/SQL function getDocument on the parser to obtain a DOMDocument interface.

Figure 11–2 Using the PL/SQL Parser API for XMLType



Example 11–9 parses a simple XML document. It creates an XML parser (instance of DBMS_XMLPARSER.parser) and uses it to parse the XML document (text) in variable indoc. Parsing creates a DOM document, which is retrieved from the parser using DBMS_XMLPARSER.getDocument. A DOM node is created that contains the entire document, and the node is printed. After freeing (destroying) the DOM document, the parser instance is freed using DBMS_XMLPARSER.freeParser.

Example 11–9 Parsing an XML Document

```
DECLARE
  indoc    VARCHAR2(2000);
  indomdoc DBMS_XMLDOM.DOMDocument;
  innode   DBMS_XMLDOM.DOMNode;
  myparser DBMS_XMLPARSER.parser;
  buf      VARCHAR2(2000);
BEGIN
  indoc := '<emp><name>De Selby</name></emp>';
  myParser := DBMS_XMLPARSER.newParser;
  DBMS_XMLPARSER.parseBuffer(myParser, indoc);
  indomdoc := DBMS_XMLPARSER.getDocument(myParser);
  innode := DBMS_XMLDOM.makeNode(indomdoc);
  DBMS_XMLDOM.writeToBuffer(innode, buf);
  DBMS_OUTPUT.put_line(buf);
  DBMS_XMLDOM.freeDocument(indomdoc);
```

```
  DBMS_XMLPARSER.freeParser(myParser);
END;
/
```

This produces the following output:

```
<emp><name>De Selby</name></emp>
```

PL/SQL XSLT Processor for XMLType (DBMS_XSLPROCESSOR)

The W3C XSL Recommendation describes rules for transforming a source tree into a result tree. A transformation expressed in Extensible Stylesheet Language Transformation (XSLT) language is called an **XSLT stylesheet**. The transformation specified is achieved by associating patterns with templates defined in the XSLT stylesheet. A template is instantiated to create part of the result tree.

Transformations and Conversions with XSLT

The Oracle XML DB PL/SQL DOM API for `XMLType` supports XSLT. This lets you transform one XML document to another, or convert XML data into HTML, PDF, or other formats. XSLT is widely used to convert XML data to HTML for web browser display.

The embedded XSLT processor follows Extensible Stylesheet Language (XSL) statements and traverses the DOM tree structure for XML data residing in `XMLType`. Oracle XML DB applications do not require a separate parser as did the prior release XML Parser for PL/SQL. However, applications requiring external processing can still use the XML Parser for PL/SQL first to expose the document structure.

Note: The XML Parser for PL/SQL in Oracle XML Developer's Kit parses an XML document (or a standalone DTD) so that the XML document can be processed by an application, typically running on the client. PL/SQL APIs for `XMLType` are used for applications that run on the server and are natively integrated in the database. Benefits include performance improvements and enhanced access and manipulation options.

See Also: Chapter 7, "Transformation and Validation of XMLType Data"

PL/SQL XSLT Processor for XMLType: Features

PL/SQL XSLT Processor for `XMLType` (`DBMS_XSLPROCESSOR`) is the Oracle XML DB implementation of the XSL processor. This follows the W3C XSLT final recommendation (REC-xslt-19991116). It includes the required action of an XSL processor in terms of how it must read XSLT stylesheets and the transformations it must achieve. It provides a convenient and efficient way of applying a single XSL stylesheet to multiple documents.

The types and methods of the PL/SQL XSLT Processor API are made available by PL/SQL package `DBMS_XSLPROCESSOR`. The methods in this package use PL/SQL data types `PROCESSOR` and `STYLESHEET`, which are specific to the XSL Processor implementation.

All `DBMS_XSLPROCESSOR` methods are supported by Oracle XML DB, with the *exception* of method `setErrorLog()`.

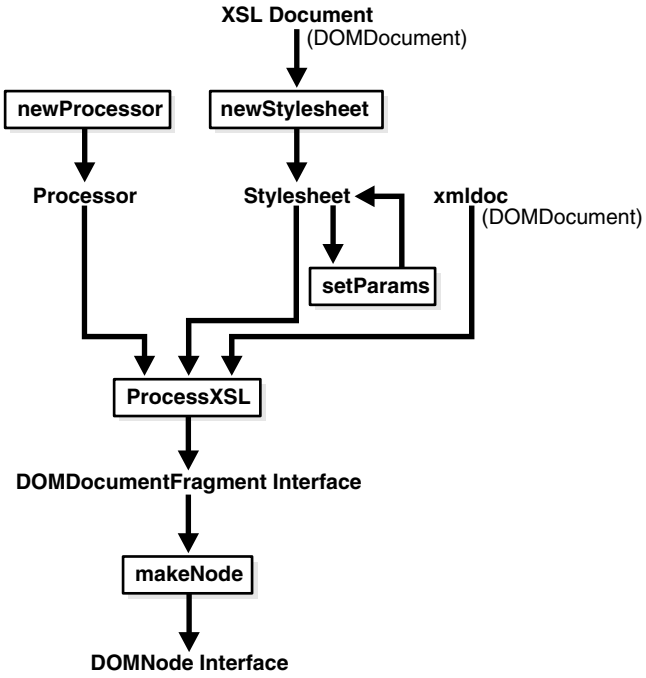
See Also: *Oracle Database PL/SQL Packages and Types Reference* for descriptions of the individual `DBMS_XSLPROCESSOR` methods

Using the PL/SQL XSLT Processor API for XMLType (DBMS_XSLPROCESSOR)

Figure 11–3 illustrates how to use XSLT Processor for `XMLType` (`DBMS_XSLPROCESSOR`). These are the steps:

1. Construct an XSLT processor using `newProcessor`.
2. Use `newStylesheet` to build a `STYLESHEET` object from a DOM document.
3. Optionally, you can set parameters for the `STYLESHEET` object using `setParams`.
4. Use `processXSL` to transform a DOM document using the processor and `STYLESHEET` object.
5. Use the PL/SQL DOM API for `XMLType` to manipulate the result of XSLT processing.

Figure 11–3 Using the PL/SQL XSLT Processor for XMLType



Example 11–10 transforms an XML document using procedure `processXSL`. It uses the same parser instance to create two different DOM documents: the XML text to transform and the XSLT stylesheet. An XSL processor instance is created, which applies the stylesheet to the source XML to produce a new DOM fragment. A DOM node (`outnode`) is created from this fragment, and the node content is printed. The output DOM fragment, parser, and XSLT processor instances are freed using procedures `freeDocFrag`, `freeParser`, and `freeProcessor`, respectively.

Example 11–10 Transforming an XML Document Using an XSL Stylesheet

```
DECLARE
  indoc      VARCHAR2(2000);
  xsldoc     VARCHAR2(2000);
  myParser   DBMS_XMLPARSER.parser;
```

```
  indomdoc   DBMS_XMLDOM.DOMDocument;
  xsltdomdoc DBMS_XMLDOM.DOMDocument;
  xsl        DBMS_XSLPROCESSOR.stylesheet;
  outdomdocf DBMS_XMLDOM.DOMDocumentFragment;
  outnode    DBMS_XMLDOM.DOMNode;
  proc       DBMS_XSLPROCESSOR.processor;
  buf        VARCHAR2(2000);
BEGIN
  indoc := '<emp><empno>1</empno>
              <fname>robert</fname>
              <lname>smith</lname>
              <sal>1000</sal>
              <job>engineer</job>
            </emp>';
  xsldoc := '<?xml version="1.0"?>
             <xsl:stylesheet version="1.0"
                             xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
               <xsl:output encoding="utf-8"/>
               <!-- alphabetizes an xml tree -->
               <xsl:template match="*">
                 <xsl:copy>
                   <xsl:apply-templates select="*|text()">
                     <xsl:sort select="name(.)" data-type="text"
                               order="ascending"/>
                   </xsl:apply-templates>
                 </xsl:copy>
               </xsl:template>
               <xsl:template match="text()">
                 <xsl:value-of select="normalize-space(.)"/>
               </xsl:template>
             </xsl:stylesheet>';
  myParser := DBMS_XMLPARSER.newParser;
  DBMS_XMLPARSER.parseBuffer(myParser, indoc);
  indomdoc   := DBMS_XMLPARSER.getDocument(myParser);
  DBMS_XMLPARSER.parseBuffer(myParser, xsldoc);
  xsltdomdoc := DBMS_XMLPARSER.getDocument(myParser);
  xsl        := DBMS_XSLPROCESSOR.newStyleSheet(xsltdomdoc, '');
  proc       := DBMS_XSLPROCESSOR.newProcessor;
  --apply stylesheet to DOM document
  outdomdocf := DBMS_XSLPROCESSOR.processXSL(proc, xsl, indomdoc);
  outnode    := DBMS_XMLDOM.makeNode(outdomdocf);
  -- PL/SQL DOM API for XMLType can be used here
  DBMS_XMLDOM.writeToBuffer(outnode, buf);
  DBMS_OUTPUT.put_line(buf);
  DBMS_XMLDOM.freeDocument(indomdoc);
  DBMS_XMLDOM.freeDocument(xsltdomdoc);
  DBMS_XMLDOM.freeDocFrag(outdomdocf);
  DBMS_XMLPARSER.freeParser(myParser);
  DBMS_XSLPROCESSOR.freeProcessor(proc);
END;
/
```

This produces the following output:

```
<emp>
<empno>1</empno>
<fname>robert</fname>
<job>engineer</job>
<lname>smith</lname>
<sal>1000</sal>
</emp>
```

12

PL/SQL Package DBMS_XMLSTORE

This chapter introduces you to PL/SQL package DBMS_XMLSTORE, which you can use to insert, update, or delete data from XML documents stored object-relationally. DBMS_XMLSTORE uses a canonical XML mapping similar to the one produced by package DBMS_XMLGEN. It converts the mapping to object-relational constructs and then inserts, updates or deletes the corresponding values in relational tables.

This chapter contains these topics:

Using Package DBMS_XMLSTORE

To use PL/SQL package DBMS_XMLSTORE, follow these steps:

1. Create a context handle by calling function DBMS_XMLSTORE.**newContext** and supplying it with the table name to use for the DML operations. For case sensitivity, double quotation mark (") the string that is passed to the function.

   By default, XML documents are expected to use the <ROW> tag to identify rows. This is the same default used by package DBMS_XMLGEN when generating XML data. You can use function setRowTag to override this behavior.

2. For *inserts*, to improve performance you can specify the list of columns to insert by calling procedure DBMS_XMLSTORE.**setUpdateColumn** for each column. The default behavior (if you do not specify the list of columns) is to insert values for each column whose corresponding element is present in the XML document.

3. For *updates*, use function DBMS_XMLSTORE.**setKeyColumn** to specify one or more (pseudo-) key columns, which are used to specify the *rows* to update. You do this in the WHERE clause of a SQL UPDATE statement. The columns that you specify need not be keys of the table, but together they must uniquely specify the rows to update.

   For example, in table employees, column employee_id uniquely identifies rows (it is a key of the table). If the XML document that you use to update the table contains element <EMPLOYEE_ID>2176</EMPLOYEE_ID>, then the rows where employee_id equals 2176 are updated.

   To improve performance, you can also specify the list of update columns using DBMS_XMLSTORE.**setUpdateColumn**. The default behavior is to update *all* of the

columns in the row(s) identified by `setKeyColumn` whose corresponding elements are present in the XML document.

4. For *deletions* you specify (pseudo-) key columns to identify the row(s) to delete. You do this the same way you specify rows to update—see step 3.
5. Provide a document to PL/SQL function `insertXML`, `updateXML`, or `deleteXML`. You can *repeat* this step to update several XML documents.
6. Close the context by calling function `DBMS_XMLSTORE.`**`closeContext`**.

Inserting an XML Document Using DBMS_XMLSTORE

To insert an XML document into a table or view, you supply the table or view name and the document. `DBMS_XMLSTORE` parses the document and then creates an `INSERT` statement into which it binds all the values. By default, `DBMS_XMLSTORE` inserts values into all the columns represented by elements in the XML document.

Example 12–1 uses `DBM_XMLSTORE` to insert the information for two new employees into the `employees` table. The information is provided in the form of XML data.

Example 12–1 Inserting Data with Specified Columns

```
SELECT employee_id AS EMP_ID, salary, hire_date, job_id, email, last_name
  FROM employees WHERE department_id = 30;

EMP_ID     SALARY HIRE_DATE JOB_ID     EMAIL       LAST_NAME
------ ---------- --------- ---------- ---------- ----------
   114      11000 07-DEC-94 PU_MAN     DRAPHEAL     Raphaely
   115       3100 18-MAY-95 PU_CLERK   AKHOO            Khoo
   116       2900 24-DEC-97 PU_CLERK   SBAIDA          Baida
   117       2800 24-JUL-97 PU_CLERK   STOBIAS        Tobias
   118       2600 15-NOV-98 PU_CLERK   GHIMURO        Himuro
   119       2500 10-AUG-99 PU_CLERK   KCOLMENA   Colmenares

6 rows selected.

DECLARE
  insCtx DBMS_XMLSTORE.ctxType;
  rows NUMBER;
  xmlDoc CLOB :=
    '<ROWSET>
       <ROW num="1">
         <EMPLOYEE_ID>920</EMPLOYEE_ID>
         <SALARY>1800</SALARY>
         <DEPARTMENT_ID>30</DEPARTMENT_ID>
         <HIRE_DATE>17-DEC-2002</HIRE_DATE>
         <LAST_NAME>Strauss</LAST_NAME>
         <EMAIL>JSTRAUSS</EMAIL>
         <JOB_ID>ST_CLERK</JOB_ID>
       </ROW>
       <ROW>
         <EMPLOYEE_ID>921</EMPLOYEE_ID>
         <SALARY>2000</SALARY>
         <DEPARTMENT_ID>30</DEPARTMENT_ID>
         <HIRE_DATE>31-DEC-2004</HIRE_DATE>
         <LAST_NAME>Jones</LAST_NAME>
         <EMAIL>EJONES</EMAIL>
         <JOB_ID>ST_CLERK</JOB_ID>
       </ROW>
```

```
    </ROWSET>';
BEGIN
  insCtx := DBMS_XMLSTORE.newContext('HR.EMPLOYEES'); -- Get saved context
  DBMS_XMLSTORE.clearUpdateColumnList(insCtx); -- Clear the update settings

  -- Set the columns to be updated as a list of values
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'EMPLOYEE_ID');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'SALARY');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'HIRE_DATE');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'DEPARTMENT_ID');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'JOB_ID');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'EMAIL');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'LAST_NAME');

  -- Insert the doc.
  rows := DBMS_XMLSTORE.insertXML(insCtx, xmlDoc);
  DBMS_OUTPUT.put_line(rows || ' rows inserted.');

  -- Close the context
  DBMS_XMLSTORE.closeContext(insCtx);
END;
/

2 rows inserted.

PL/SQL procedure successfully completed.

SELECT employee_id AS EMP_ID, salary, hire_date, job_id, email, last_name
  FROM employees WHERE department_id = 30;

EMP_ID     SALARY HIRE_DATE JOB_ID     EMAIL       LAST_NAME
------ ---------- --------- ---------- ---------- ----------
   114      11000 07-DEC-94 PU_MAN     DRAPHEAL     Raphaely
   115       3100 18-MAY-95 PU_CLERK   AKHOO            Khoo
   116       2900 24-DEC-97 PU_CLERK   SBAIDA          Baida
   117       2800 24-JUL-97 PU_CLERK   STOBIAS        Tobias
   118       2600 15-NOV-98 PU_CLERK   GHIMURO        Himuro
   119       2500 10-AUG-99 PU_CLERK   KCOLMENA   Colmenares
   920       1800 17-DEC-02 ST_CLERK   STRAUSS       Strauss
   921       2000 31-DEC-04 ST_CLERK   EJONES          Jones

8 rows selected.
```

Updating XML Data Using DBMS_XMLSTORE

To update (modify) existing data using package `DBMS_XMLSTORE`, you must specify which rows to update. In SQL, you would do that using a `WHERE` clause in an `UPDATE` statement. With `DBMS_XMLSTORE`, you do it by calling procedure `setKeyColumn` once for *each* of the columns that are used collectively to identify the row.

You can think of this set of columns as acting like a set of key columns: *together, they specify a unique row* to be updated. However, the columns that you use (with `setKeyColumn`) need *not* be keys of the table—as long as they uniquely specify a row, they can be used with calls to `setKeyColumn`.

Example 12–2 uses `DBM_XMLSTORE` to update information. Assuming that the first name for employee number 188 is incorrectly recorded as Kelly, this example corrects that first name to Pat. Since column `employee_id` is a primary key for table `employees`, a

single call to `setKeyColumn` specifying column `employee_id` is sufficient to identify a unique row for updating.

Example 12–2 Updating Data with Key Columns

```
SELECT employee_id, first_name FROM employees WHERE employee_id = 188;

EMPLOYEE_ID FIRST_NAME
----------- ----------
        188 Kelly

1 row selected.

DECLARE
  updCtx DBMS_XMLSTORE.ctxType;
  rows NUMBER;
  xmlDoc CLOB :=
    '<ROWSET>
       <ROW>
         <EMPLOYEE_ID>188</EMPLOYEE_ID>
         <FIRST_NAME>Pat</FIRST_NAME>
       </ROW>
     </ROWSET>';
BEGIN
   updCtx := DBMS_XMLSTORE.newContext('HR.EMPLOYEES'); -- get the context
   DBMS_XMLSTORE.clearUpdateColumnList(updCtx);        -- clear update settings

   -- Specify that column employee_id is a "key" to identify the row to update.
   DBMS_XMLSTORE.setKeyColumn(updCtx, 'EMPLOYEE_ID');
   rows := DBMS_XMLSTORE.updateXML(updCtx, xmlDoc);    -- update the table
   DBMS_XMLSTORE.closeContext(updCtx);                 -- close the context
END;
/

SELECT employee_id, first_name FROM employees WHERE employee_id = 188;

EMPLOYEE_ID FIRST_NAME
----------- ----------
        188 Pat

1 row selected.
```

The following `UPDATE` statement is equivalent to the use of `DBM_XMLSTORE` in Example 12–2:

```
UPDATE hr.employees SET first_name = 'Pat' WHERE employee_id = 188;
```

Deleting XML Data Using DBMS_XMLSTORE

Deletions are treated similarly to updates: you specify the key or pseudo-key columns that identify the rows to delete.

Example 12–3 DBMS_XMLSTORE.DELETEXML Example

```
SELECT employee_id FROM employees WHERE employee_id = 188;

EMPLOYEE_ID
-----------
        188
```

```
1 row selected.

DECLARE
  delCtx DBMS_XMLSTORE.ctxType;
  rows NUMBER;
  xmlDoc CLOB :=
    '<ROWSET>
       <ROW>
         <EMPLOYEE_ID>188</EMPLOYEE_ID>
         <DEPARTMENT_ID>50</DEPARTMENT_ID>
       </ROW>
     </ROWSET>';
BEGIN
  delCtx  := DBMS_XMLSTORE.newContext('HR.EMPLOYEES');
  DBMS_XMLSTORE.setKeyColumn(delCtx, 'EMPLOYEE_ID');
  rows := DBMS_XMLSTORE.deleteXML(delCtx, xmlDoc);
  DBMS_XMLSTORE.closeContext(delCtx);
END;
/

SELECT employee_id FROM employees WHERE employee_id = 188;

no rows selected.
```

13

Java DOM API for XMLType

This chapter describes how to use the Java DOM API to manipulate `XMLType` in Java, including fetching `XMLType` data through Java Database Connectivity (JDBC).

This chapter contains these topics:

- Overview of Java DOM API for XMLType
- Java DOM API for XMLType
- Loading a Large XML Document into the Database Using JDBC
- Java DOM API for XMLType Features
- Java DOM API for XMLType Classes
- Large XML Node Handling with Java
- Using the Java DOM API and JDBC with Binary XML

See Also: "Using XQuery with XQJ to Access Database Data" on page 5-22

Overview of Java DOM API for XMLType

Oracle XML DB supports the Java Document Object Model (DOM) Application Program Interface (API) for `XMLType`. This is a generic API for client and server, for both XML schema-based and non-schema-based documents. It is implemented using Java package `oracle.xml.parser.v2`. DOM is a tree-based object representation of XML documents in dynamic memory that enables programmatic access to their elements and attributes. The DOM object and interface are part of a W3C recommendation. DOM views the parsed document as a tree of objects.

To access `XMLType` data using JDBC, use the class `oracle.xdb.XMLType`.

For XML documents that do not conform to any XML schema, use the Java DOM API for `XMLType`, because it can handle *any* valid XML document.

See Also: *Oracle Database XML Java API Reference*

Java DOM API for XMLType

Java DOM API for `XMLType` handles all kinds of valid XML documents, irrespective of how they are stored in Oracle XML DB. It presents to the application a uniform view of the XML document, whether it is XML schema-based or non-schema-based and whatever the underlying `XMLType` storage model. Java DOM API works on both client and server.

As discussed in Chapter 11, "PL/SQL APIs for XMLType", the Oracle XML DB DOM APIs are compliant with the W3C DOM Level 1.0 and Level 2.0 Core Recommendation.

The Java DOM API for `XMLType` can be used to construct an `XMLType` instance from data encoded in different character sets.

You can use the Java DOM API for `XMLType` to access XML documents stored in Oracle XML DB Repository from Java applications. Naming conforms to the Java binding for DOM as specified by the W3C DOM Recommendation. The repository can contain both XML schema-based and non-schema-based documents.

Accessing XMLType Data Using JDBC

JDBC is a SQL-based way for Java applications to access any data in Oracle Database, including XML documents in Oracle XML DB. You use Java class `oracle.xdb.XMLType`, method `createXML()` to create XML data.

Note: Use the thick driver with method `XMLType.createXML()` if you pass a stream as input. You cannot use the thin driver in this case.

Using XMLType Data with JDBC

The JDBC 4.0 standard data type for XML data is `java.sql.SQLXML`. Method `getObject()` returns an object of type `oracle.xdb.XMLType`. Starting with Oracle Database 11*g* Release 2 (11.2.0.3), `oracle.xdb.XMLType` implements interface `java.sql.SQLXML`.

How Java Applications Use JDBC to Access XML Documents in Oracle XML DB

JDBC users can query an `XMLType` table to obtain a JDBC `XMLType` interface that supports all SQL/XML functions supported by SQL data type `XMLType`. The Java (JDBC) API for `XMLType` interface can implement the DOM document interface.

Example 13–1 illustrates how to use JDBC to query an `XMLType` table:

Example 13–1 Querying an XMLType Table Using JDBC

```
import oracle.xdb.XMLType;
...
OraclePreparedStatement stmt = (OraclePreparedStatement)
conn.prepareStatement("SELECT e.poDoc FROM po_xml_tab e");
ResultSet rset = stmt.executeQuery();
OracleResultSet orset = (OracleResultSet) rset;
while(orset.next())
{
  // get the XMLType
  XMLType poxml = (XMLType)orset.getObject(1);
  // get the XMLDocument as a string...
  Document podoc = (Document)poxml.getDOM();
}
```

You can select `XMLType` data using JDBC in any of these ways:

- Use SQL/XML function `XMLSerialize` in SQL, and obtain the result as an `oracle.sql.CLOB`, `java.lang.String` or `oracle.sql.BLOB` in Java. The Java snippet in Example 13–2 illustrates this.

- Call method `getObject()` in the `PreparedStatement` to obtain the whole `XMLType` instance. The return value of this method is of type `oracle.xdb.XMLType`. Then you can use Java functions on class `XMLType` to access the data. Example 13–3 shows how to do this.

Example 13–2 Selecting XMLType Data Using getStringVal() and getCLOB()

```
DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());
Connection conn =
  DriverManager.getConnection("jdbc:oracle:oci8:@", "QUINE", "CURRY");
OraclePreparedStatement stmt =
  (OraclePreparedStatement) conn.prepareStatement(
     "SELECT XMLSerialize(DOCUMENT e.poDoc AS CLOB) poDoc, " +
     "XMLSerialize(DOCUMENT e.poDoc AS VARCHAR2(2000)) poString " +
     " FROM po_xml_tab e");
ResultSet rset = stmt.executeQuery();
OracleResultSet orset = (OracleResultSet) rset;
while(orset.next())
{
  // the first argument is a CLOB
  oracle.sql.CLOB clb = orset.getCLOB(1);
  // the second argument is a string..
  String poString = orset.getString(2);
  // now use the CLOB inside the program
}
```

Example 13–3 shows the use of method `getObject()` to directly obtain an `XMLType` instance from `ResultSet`.

Example 13–3 Returning XMLType Data Using getObject()

```
import oracle.xdb.XMLType;
...
PreparedStatement stmt = conn.prepareStatement(
                           "SELECT e.poDoc FROM po_xml_tab e");
ResultSet rset = stmt.executeQuery();
while(rset.next())
{
  // get the XMLType
  XMLType poxml = (XMLType)rset.getObject(1);
  // get the XML as a string...
  String poString = poxml.getStringVal();
}
```

Example 13–4 shows how to bind an output parameter of type `XMLType` to a SQL statement. The output parameter is registered as having data type `XMLType`.

Example 13–4 Returning XMLType Data Using an Output Parameter

```
public void doCall (String[] args) throws Exception
{
  //  CREATE OR REPLACE FUNCTION getPurchaseOrder(reference VARCHAR2)
  //  RETURN XMLTYPE
  //  AS
  //    xml XMLTYPE;
  //  BEGIN
  //    SELECT OBJECT_VALUE INTO xml
  //      FROM purchaseorder
  //      WHERE XMLCast(XMLQuery('$p/PurchaseOrder/Reference'
  //                             PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
```

```
  //                    AS VARCHAR2(30))
  //            = reference;
  //      RETURN xml;
  //  END;
  String SQLTEXT = "{? = call getPurchaseOrder('BLAKE-2002100912333601PDT')}";
  CallableStatement sqlStatement = null;
  XMLType xml = null;
  super.doSomething(args);
  createConnection();
  try
  {
    System.out.println("SQL := " + SQLTEXT);
    sqlStatement = getConnection().prepareCall(SQLTEXT);
    sqlStatement.registerOutParameter (1, OracleTypes.OPAQUE,"SYS.XMLTYPE");
    sqlStatement.execute();
    xml = (XMLType) sqlStatement.getObject(1);
    System.out.println(xml.getStringVal());
  }
  catch (SQLException SQLe)
  {
    if (sqlStatement != null)
    {
      sqlStatement.close();
      throw SQLe;
    }
  }
}
```

Manipulating XML Database Documents Using JDBC

You can also update, insert, and delete `XMLType` data using Java Database Connectivity (JDBC).

> **Note:** `XMLType` methods `extract()`, `transform()`, and `existsNode()` work only with the OCI driver.
>
> Not all `oracle.xdb.XMLType` functions are supported by the thin JDBC driver. If you do not use `oracle.xdb.XMLType` classes and the OCI driver, you could lose performance benefits associated with the intelligent handling of XML.

You can update, insert, or delete `XMLType` data in either of these ways:

- Bind a `CLOB` instance or a string to an `INSERT`, `UPDATE`, or `DELETE` statement, and use the `XMLType` constructor inside SQL to construct the XML instance. Example 13–5 illustrates this.
- Use `setObject()` in the `PreparedStatement` to set the entire `XMLType` instance. Example 13–6 illustrates this.

Example 13–5 Updating XMLType Data Using SQL UPDATE with Constructor XMLType

```
OraclePreparedStatement stmt =
    (OraclePreparedStatement) conn.prepareStatement(
                                "UPDATE po_xml_tab SET poDoc = XMLType(?)");
// the second argument is a string..
String poString = "<PO><PONO>200</PONO><PNAME>PO_2</PNAME></PO>";
// now bind the string..
stmt.setString(1,poString);
```

```
stmt.execute();
```

Example 13–6 Updating XMLType Data Using SQL UPDATE with setObject()

```
import oracle.xdb.XMLType;
...
OraclePreparedStatement stmt =
  (OraclePreparedStatement) conn.prepareStatement(
                              "UPDATE po_xml_tab SET poDoc = ?");
// the second argument is a string
String poString = "<PO><PONO>200</PONO><PNAME>PO_2</PNAME></PO>";
XMLType poXML = XMLType.createXML(conn, poString);
// now bind the string..
stmt.setObject(1,poXML);
stmt.execute();
```

When selecting `XMLType` values, JDBC describes the column as an opaque type. You can select the column type name and compare it with `XMLTYPE` to see whether you are dealing with an `XMLType` instance. Example 13–7 illustrates this.

Example 13–7 Retrieving Metadata about XMLType Data Using JDBC

```
import oracle.sql.*;
import oracle.jdbc.*;
...
OraclePreparedStatement stmt =
    (OraclePreparedStatement) conn.prepareStatement(
        "SELECT poDoc FROM po_xml_tab");
OracleResultSet rset = (OracleResultSet)stmt.executeQuery();
// Get the resultset metadata
OracleResultSetMetaData mdata =
        (OracleResultSetMetaData)rset.getMetaData();
// Describe the column = the column type comes out as OPAQUE
// and column type name comes out as XMLTYPE
if (mdata.getColumnType(1) == OracleTypes.OPAQUE &&
    mdata.getColumnTypeName(1).compareTo("SYS.XMLTYPE") == 0)
{
   // It is an XMLtype instance
}
```

Example 13–8 updates element `discount` inside element `PurchaseOrder` stored in an `XMLType` column. It uses JDBC and class `oracle.xdb.XMLType`. It uses the XML parser to update a DOM tree and write the updated XML value to the `XMLType` column.

Example 13–8 Updating an Element in an XMLType Column Using JDBC

```
-- Create po_xml_hist table to store old PurchaseOrders
CREATE TABLE po_xml_hist (xpo XMLType);
/* NOTE: You must have xmlparserv2.jar and xdb.jar in CLASSPATH */
import java.sql.*;
import java.io.*;
import oracle.xml.parser.v2.*;
import org.xml.sax.*;
import org.w3c.dom.*;
import oracle.jdbc.driver.*;
import oracle.sql.*;
import oracle.xdb.XMLType;
public class tkxmtpje
{
  static String conStr = "jdbc:oracle:oci8:@";
```

```
  static String user = "QUINE";
  static String pass = "CURRY";
  static String qryStr =
  "SELECT x.poDoc from po_xml_tab x " +
  "WHERE XMLCast(XMLQuery('/PO/PONO/text()'" +
  " PASSING x.poDoc RETURNING CONTENT)" +
  " AS NUMBER)" +
  " = 200";
  static String updateXML(String xmlTypeStr)
  Java DOM API for XMLType
  Beta Draft Java DOM API for XMLType 15-7
  {
    System.out.println("\n================================");
    System.out.println("xmlType.getStringVal():");
    System.out.println(xmlTypeStr);
    System.out.println("================================");
    String outXML = null;
    try
    {
      DOMParser parser = new DOMParser();
      parser.setValidationMode(false);
      parser.setPreserveWhitespace (true);
      parser.parse(new StringReader(xmlTypeStr));
      System.out.println("xmlType.getStringVal(): xml String is well-formed");
      XMLDocument doc = parser.getDocument();
      NodeList nl = doc.getElementsByTagName("DISCOUNT");
      for(int i=0;i<nl.getLength();i++)
      {
        XMLElement discount = (XMLElement)nl.item(i);
        XMLNode textNode = (XMLNode)discount.getFirstChild();
        textNode.setNodeValue("10");
      }
      StringWriter sw = new StringWriter();
      doc.print(new PrintWriter(sw));
      outXML = sw.toString();
      //print modified xml
      System.out.println("\n================================");
      System.out.println("Updated PurchaseOrder:");
      System.out.println(outXML);
      System.out.println("================================");
    }
    catch (Exception e)
    {
      e.printStackTrace(System.out);
    }
    return outXML;
  }
}
public static void main(String args[]) throws Exception
{
  try
  {
    System.out.println("qryStr=" + qryStr);
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());
    Connection conn =
    DriverManager.getConnection("jdbc:oracle:oci8:@", user, pass);
    Statement s = conn.createStatement();
    OraclePreparedStatement stmt;
    ResultSet rset = s.executeQuery(qryStr);
    OracleResultSet orset = (OracleResultSet) rset;
```

```
    while(orset.next())
    {
      //retrieve PurchaseOrder xml document from database
      XMLType xt = (XMLType)orset.getObject(1);
      //store this PurchaseOrder in po_xml_hist table
      stmt = (OraclePreparedStatement)conn.prepareStatement(
      "INSERT INTO po_xml_hist VALUES(?)");
      stmt.setObject(1,xt); // bind the XMLType instance
      stmt.execute();
      //update "DISCOUNT" element
      String newXML = updateXML(xt.getStringVal());
      // create a new instance of an XMLtype from the updated value
      xt = XMLType.createXML(conn, newXML);
      // update PurchaseOrder xml document in database
      stmt = (OraclePreparedStatement)conn.prepareStatement(
      "UPDATE po_xml_tab x SET x.poDoc =? WHERE " +
      "XMLCast(XMLQuery('/PO/PONO/text()'" +
      " PASSING value(xmltab) RETURNING CONTENT)" +
      " AS NUMBER)" +
      "= 200");
      stmt.setObject(1,xt); // bind the XMLType instance
      stmt.execute();
      conn.commit();
      System.out.println("PurchaseOrder 200 Updated!");
    }
    //delete PurchaseOrder 1001
    s.execute("DELETE FROM po_xml x WHERE" +
              "XMLCast(XMLQuery('/PurchaseOrder/PONO/text()'" +
              " PASSING value(xmltab) RETURNING CONTENT)" +
              " AS NUMBER)" +
              "= 1001");
    System.out.println("PurchaseOrder 1001 deleted!");
  }
  catch(Exception e)
  {
    e.printStackTrace(System.out);
  }
}
SELECT x.xpo.getCLOBVal() FROM po_xml x;
```

Example 13–9 shows the updated purchase order that results from Example 13–8.

Example 13–9 Updated Purchase-Order Document

```
<?xml version = "1.0"?>
<PurchaseOrder>
  <PONO>200</PONO>
  <CUSTOMER>
   <CUSTNO>2</CUSTNO>
   <CUSTNAME>John Nike</CUSTNAME>
   <ADDRESS>
    <STREET>323 College Drive</STREET>
    <CITY>Edison</CITY>
    <STATE>NJ</STATE>
    <ZIP>08820</ZIP>
   </ADDRESS>
   <PHONELIST>
    <VARCHAR2>609-555-1212</VARCHAR2>
    <VARCHAR2>201-555-1212</VARCHAR2>
   </PHONELIST>
```

```
  </CUSTOMER>
  <ORDERDATE>20-APR-97</ORDERDATE>
  <SHIPDATE>20-MAY-97 12.00.00.000000 AM</SHIPDATE>
  <LINEITEMS>
   <LINEITEM_TYP LineItemNo="1">
    <ITEM StockNo="1004">
     <PRICE>6750</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>1</QUANTITY>
    <DISCOUNT>10</DISCOUNT>
   </LINEITEM_TYP>
   <LINEITEM_TYP LineItemNo="2">
    <ITEM StockNo="1011">
     <PRICE>4500.23</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>2</QUANTITY>
    <DISCOUNT>10</DISCOUNT>
   </LINEITEM_TYP>
  </LINEITEMS>
  <SHIPTOADDR>
   <STREET>55 Madison Ave</STREET>
   <CITY>Madison</CITY>
   <STATE>WI</STATE>
   <ZIP>53715</ZIP>
  </SHIPTOADDR>
</PurchaseOrder>
```

Example 13–10 does all of the following:

- Selects an XMLType instance from an XMLType table
- Extracts portions of the XMLType instance, based on an XPath expression
- Checks for the existence of elements
- Transforms the XMLType instance to another XML format based on XSL
- Checks the validity of the XMLType document against an XML schema

Example 13–10 Manipulating an XMLType Column Using JDBC

```
import java.sql.*;
import java.io.*;
import java.net.*;
import java.util.*;
import oracle.xml.parser.v2.*;
import oracle.xml.parser.schema.*;
import org.xml.sax.*;
import org.w3c.dom.*;
import oracle.xml.sql.dataset.*;
import oracle.xml.sql.query.*;
import oracle.xml.sql.docgen.*;
import oracle.xml.sql.*;
import oracle.jdbc.driver.*;
import oracle.sql.*;
import oracle.xdb.XMLType;
public class tkxmtpk1
{
  static String conStr = "jdbc:oracle:oci8:@";
  static String user = "tpjc";
```

```
static String pass = "tpjc";
static String qryStr = "select x.resume from t1 x where id<3";
static String xslStr =
  "<?xml version='1.0'?> " +
  "<xsl:stylesheet version='1.0' xmlns:xsl='http://www.w3.org/1" +
  "999/XSL/Transform'> " +
  "<xsl:template match='ROOT'> " +
  "<xsl:apply-templates/> " +
  "</xsl:template> " +
  "<xsl:template match='NAME'> " +
  "<html> " +
  " <body> " +
  " This is Test " +
  " </body> " +
  "</html> " +
  "</xsl:template> " +
  "</xsl:stylesheet>";
static void parseArg(String args[])
{
  conStr = (args.length >= 1 ? args[0]:conStr);
  user = (args.length >= 2 ? args[1].substring(0, args[1].indexOf("/")):user);
  pass = (args.length >= 2 ? args[1].substring(args[1].indexOf("/")+1):pass);
  qryStr = (args.length >= 3 ? args[2]:qryStr);
}
/**
* Print the byte array contents
*/
static void showValue(byte[] bytes) throws SQLException
{
  if (bytes == null)
  System.out.println("null");
  else if (bytes.length == 0)
  System.out.println("empty");
  else
  {
    for(int i=0; i<bytes.length; i++)
      System.out.print((bytes[i]&0xff)+" ");
    System.out.println();
  }
}
public static void main(String args[]) throws Exception
{
  tkxmjnd1 util = new tkxmjnd1();
  try
  {
    if(args != null)
      parseArg(args);
    // System.out.println("conStr=" + conStr);
    System.out.println("user/pass=" + user + "/" +pass );
    System.out.println("qryStr=" + qryStr);
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());
    Connection conn = DriverManager.getConnection(conStr, user, pass);
    Statement s = conn.createStatement();
    ResultSet rset = s.executeQuery(qryStr);
    OracleResultSet orset = (OracleResultSet) rset;
    OPAQUE xml;
    while(orset.next())
    {
      oracle.xdb.XMLType xt = (oracle.xdb.XMLType)(orset.getObject(1));
      System.out.println("Testing getDOM() ...");
```

```
Document doc = xt.getDOM();
util.printDocument(doc);
System.out.println("Testing getBytesValue() ...");
showValue(xt.getBytesValue());
System.out.println("Testing existsNode() ...");
try
{
  System.out.println("existsNode(/)" + xt.existsNode("/", null));
}
catch (SQLException e)
{
  System.out.println("Thin driver Expected exception: " + e);
}
System.out.println("Testing extract() ...");
try
{
  XMLType xt1 = xt.extract("/RESUME", null);
  System.out.println("extract RESUME: " + xt1.getStringVal());
  System.out.println("should be Fragment: " + xt1.isFragment());
}
catch (SQLException e)
{
  System.out.println("Thin driver Expected exception: " + e);
}
System.out.println("Testing isFragment() ...");
try
{
  System.out.println("isFragment = " + xt.isFragment());
}
catch (SQLException e)
{
  System.out.println("Thin driver Expected exception: " + e);
}
System.out.println("Testing isSchemaValid() ...");
try
{
  System.out.println("isSchemaValid(): " +
                     xt.isSchemaValid(null,"RES UME"));
}
catch (SQLException e)
{
  System.out.println("Thin driver Expected exception: " + e);
}
System.out.println("Testing transform() ...");
System.out.println("XSLDOC: \n" + xslStr + "\n");
try
{
  /* XMLType xslDoc = XMLType.createXML(conn, xslStr);
     System.out.println("XSLDOC Generated");
     System.out.println("After transformation:\n" +
                        (xt.transform(xslDoc,
                         null)).getStringVal());
   */
   System.out.println("After transformation:\n" +
                      (xt.transform(null,
                       null)).getStringVal());
}
catch (SQLException e)
{
  System.out.println("Thin driver Expected exception: " + e);
```

```
        }
        System.out.println("Testing createXML(conn, doc) ...");
        try
        {
          XMLType xt1 = XMLType.createXML(conn, doc);
          System.out.println(xt1.getStringVal());
        }
        catch (SQLException e)
        {
          System.out.println("Got exception: " + e);
        }
      }
    }
    catch(Exception e)
    {
      e.printStackTrace(System.out);
    }
  }
}
```

Loading a Large XML Document into the Database Using JDBC

If a large XML document (greater than 4000 characters, typically) is inserted into an `XMLType` table or column using a `String` object in JDBC, this run-time error occurs:

```
"java.sql.SQLException: Data size bigger than max size for this type"
```

This error can be avoided by using a Java `CLOB` object to hold the large XML document. Example 13–11 shows code that uses this technique. It defines `XMLType` method `insertXML()`, which can be used to insert a large XML document into `XMLType` column `purchaseOrder` of table `poTable`. The same approach can be used for an `XMLType` table.

Method `insertXML()` uses a `CLOB` object that contains the XML document. It creates the `CLOB` object using class `oracle.sql.CLOB` on the client side. This class is the Oracle JDBC driver implementation of the standard JDBC interface `java.sql.Clob`. Method `insertXML()` binds the `CLOB` object to a JDBC prepared statement, which inserts the data into the `XMLType` column.

The prerequisites for using `insertXML()` are as follows:

- Oracle Database, release 9.2.0.1 or later.
- The target database table. Execute the following SQL before running the example:

  ```
  CREATE TABLE poTable (purchaseOrder XMLType);
  ```

The formal parameters of `XMLType` method `insertXML()` are as follows:

- *`xmlData`* – XML data to be inserted into the `XMLType` column
- *`conn`* – database connection object (Oracle Connection Object)

Example 13–11 Java Method insertXML()

```
...
import oracle.sql.CLOB;
import java.sql.Connection;
import java.sql.SQLException;
import java.sql.PreparedStatement;
...
private void insertXML(String xmlData, Connection conn)
{
```

```
  CLOB clob = null;
  String query;
  // Initialize statement Object
  PreparedStatement pstmt = null;
  try
  {
    query = "INSERT INTO potable (purchaseOrder) VALUES (XMLType(?)) ";
    // Get the statement Object
    pstmt = conn.prepareStatement(query);
    // xmlData is the string that contains the XML Data.
    // Get the CLOB object.
    clob = getCLOB(xmlData, conn);
    // Bind this CLOB with the prepared Statement
    pstmt.setObject(1, clob);
    // Execute the Prepared Statement
    if (pstmt.executeUpdate () == 1)
    {
      System.out.println ("Successfully inserted a Purchase Order");
    }
  }
  catch(SQLException sqlexp)
  {
    sqlexp.printStackTrace();
  }
  catch(Exception exp)
  {
    exp.printStackTrace();
  }
}
```

Java method `insertXML()` calls method `getCLOB()` to create and return the `CLOB` object that holds the XML data. The formal parameters of method `getCLOB()`, which is defined in Example 13–12, are as follows:

- *`xmlData`* – XML data to be inserted into the `XMLType` column
- *`conn`* – database connection object (Oracle Connection Object)

Example 13–12 Java Method getCLOB()

```
...
import oracle.sql.CLOB;
import java.sql.Connection;
import java.sql.SQLException;
import java.io.Writer;
...
private CLOB getCLOB(String xmlData, Connection conn) throws SQLException
{
  CLOB tempClob = null;
  try
  {
    // If the temporary CLOB has not yet been created, create one
    tempClob = CLOB.createTemporary(conn, true, CLOB.DURATION_SESSION);
    // Open the temporary CLOB in readwrite mode, to enable writing
    tempClob.open(CLOB.MODE_READWRITE);
    // Get the output stream to write
    Writer tempClobWriter = tempClob.getCharacterOutputStream();
    // Write the data into the temporary CLOB
    tempClobWriter.write(xmlData);
    // Flush and close the stream
    tempClobWriter.flush();
```

```
    tempClobWriter.close();
    // Close the temporary CLOB
    tempClob.close();
  }
  catch(SQLException sqlexp)
  {
    tempClob.freeTemporary();
    sqlexp.printStackTrace();
  }
  catch(Exception exp)
  {
    tempClob.freeTemporary();
    exp.printStackTrace();
  }
  return tempClob;
}
```

See Also: *Oracle Database SecureFiles and Large Objects Developer's Guide*

Java DOM API for XMLType Features

When you use the Java DOM API to retrieve XML data from Oracle XML DB:

- If the connection is *thin*, you get an **`XML`**`Document` instance
- If the connection is *thick* or *kprb*, you get an **`XDB`**`Document` instance with method `getDOM()` and an **`XML`**`Document` instance with method `getDocument()`. Method `getDOM()` and class `XDBDocument` are deprecated.

Both `XMLDocument` and `XDBDocument` (which is deprecated) are instances of the W3C Document Object Model (DOM) interface. From this document interface you can access the document elements and perform all the operations specified in the W3C DOM Recommendation. The DOM works on:

- Any type of XML document, schema-based or non-schema-based
- Either type of underlying storage used by the document:
  - Binary Large Object (BLOB)
  - object-relational

The Java DOM API for `XMLType` supports deep and shallow searching in the document to retrieve children and properties of XML objects such as name, namespace, and so on. Conforming to the DOM 2.0 recommendation, Java DOM API for `XMLType` is namespace aware.

The Java API for `XMLType` also lets applications create XML documents programmatically, even on the fly (dynamically). Such documents can conform to a registered XML schema or not.

Permissions on MS Windows for Java DOM API, a Thick Connection, and Java Security Manager

If you use Java Security Manager (class `SecurityManager`) on MS Windows to implement a security policy for your application, then you must add the permissions detailed here to your security policy file, in order to use the Java DOM API for `XMLType` with a thick connection.

Example 13–13 shows the contents of such a policy file, where the workspace folder that contains the jars related to Oracle XML DB is `c:\myworkspace`. (The policy file must be in the same folder.)

The libraries used in Example 13–13 are `orageneric12` and `oraxml12`. The last two characters (`12` here) must correspond to your major database release number (so for Oracle Database 13 Release 2, for example, you would use `orageneric`**`13`** and `oraxml`**`13`**).

Example 13–13 Policy File Granting Permissions for Java DOM API

```
grant codeBase "file:c:\myworkspace" {
  permission java.lang.RuntimePermission "loadLibrary.orageneric12";
  permission java.lang.RuntimePermission "loadLibrary.oraxml12";
}

grant codeBase "file:c:\myworkspace\xdb6.jar" {
  permission java.lang.RuntimePermission "loadLibrary.orageneric12";
  permission java.lang.RuntimePermission "loadLibrary.oraxml12";
}

grant codeBase "file:c:\myworkspace\ojdbc6.jar" {
  permission java.lang.RuntimePermission "loadLibrary.orageneric12";
  permission java.lang.RuntimePermission "loadLibrary.oraxml12";
}
```

After you have created the policy file, you can invoke your program using the following command-line switches:

```
-Djava.security.manager=default -Djava.security.policy=c:\myworkspace\ojdbc.policy
```

Creating XML Schema-Based Documents

To create XML schema-based documents, Java DOM API for `XMLType` uses an extension to specify which XML schema URL to use. For XML schema-based documents, it also verifies that the DOM being created conforms to the specified XML schema, that is, that the appropriate children are being inserted under the appropriate documents.

> **Note:** The Java DOM API for `XMLType` does *not* perform type and constraint checks.

Once the DOM object has been created, it can be saved to Oracle XML DB Repository using the Oracle XML DB resource API for Java. The XML document is stored in the appropriate format:

- As a BLOB instance for non-schema-based documents.
- In the format specified by the XML schema for XML schema-based documents.

Example 13–14 shows how you can use the Java DOM API for `XMLType` to create a DOM object and store it in the format specified by the associated XML schema. Validation against the XML schema is not shown here.

Example 13–14 Creating a DOM Object with the Java DOM API

```
import oracle.xdb.XMLType;
...
OraclePreparedStatement stmt =
```

```
    (OraclePreparedStatement) conn.prepareStatement(
                                "update po_xml_XMLTypetab set poDoc = ? ");
// the second argument is a string
String poString = "<PO><PONO>200</PONO><PNAME>PO_2</PNAME></PO>";
XMLType poXML = XMLType.createXML(conn, poString);
Document poDOM = (Document)poXML.getDOM();
Element rootElem = poDOM.createElement("PO");
poDOM.insertBefore(poDOM, rootElem, null);
// now bind the string..
stmt.setObject(1,poXML);
stmt.execute();
```

JDBC or SQLJ

An `XMLType` instance is represented in Java by `oracle.xdb.XMLType`. When an instance of `XMLType` is fetched using JDBC, it is automatically manifested as an object of the provided `XMLType` class. Similarly, objects of this class can be bound as values to Data Manipulation Language (DML) statements where an `XMLType` is expected. The same action is supported in SQLJ clients.

Java DOM API for XMLType Classes

Oracle XML DB supports the W3C DOM Level 2 Recommendation. In addition to the W3C Recommendation, Oracle XML DB DOM API also provides Oracle-specific extensions, to facilitate your application interfacing with Oracle XML Developer's Kit for Java. A list of the Oracle extensions is available at:

http://www.oracle.com/technetwork/database-features/xmldb/overview/index.html

`XMLDocument` is a class that represents the DOM for the instantiated XML document. You can retrieve the `XMLType` value from the XML document using the constructor `XMLType` constructor that takes a `Document` argument:

```
XMLType createXML(Connection conn, Document domdoc)
```

Table 13–1 lists the Java DOM API for `XMLType` classes and the W3C DOM interfaces they implement. The Java DOM API classes are all in package `oracle.xml.parser.v2`.

Table 13–1 Java DOM API for XMLType: Classes

Java DOM API for XMLType Class	W3C DOM Interface Recommendation Class
XMLDocument	org.w3c.dom.Document
XMLCDATA	org.w3c.dom.CDataSection
XMLComment	org.w3c.dom.Comment
XMLPI	org.w3c.dom.ProcessingInstruction
XMLText	org.w3c.dom.Text
XMLEntity	org.w3c.dom.Entity
DTD	org.w3c.dom.DocumentType
XMLNotation	org.w3c.dom.Notation
XMLAttr	org.w3c.dom.Attribute
XMLDomImplementation	org.w3c.dom.DOMImplementation
XMLElement	org.w3c.dom.Element
XMLAttrList	org.w3c.dom.NamedNodeMap

Table 13–1 (Cont.) Java DOM API for XMLType: Classes

Java DOM API for XMLType Class	W3C DOM Interface Recommendation Class
XMLNode	org.w3c.dom.Node

Java Methods That Are Deprecated or Not Supported

The following methods documented in release 2 (9.2.0.1) are no longer supported:

- XDBDocument.getElementByID
- XDBDocument.importNode
- XDBNode.normalize
- XDBNode.isSupported
- XDBDomImplementation.hasFeature

In addition, in releases prior to Oracle Database 11*g* Release 1, a different API, in package oracle.xdb.dom, was used for the Java DOM. Please refer to the documentation for such releases for more information on that deprecated API. The following classes in oracle.xdb.dom are *deprecated*. Use oracle.xml.parser.v2 classes instead.

- XDBAttribute – use XMLAttr
- XDBBinaryDocument
- XDBCData – use XMLCDATA
- XDBComment – use XMLComment
- XDBDocFragment – use XMLDocumentFragment
- XDBDocument – use XMLDocument
- XDBDocumentType – use DTD
- XDBDOMException – use XMLDomException
- XDBDomImplementation – use XMLDomImplementation
- XDBElement – use XMLElement
- XDBEntity – use XMLEntity
- XDBEntityReference – use XMLEntityReference
- XDBNamedNodeMap – use XMLAttrList
- XDBNode – use XMLNode
- XDBNodeList – use NodeList
- XDBNotation – use XMLNotation
- XDBProcInst – use XMLPI
- XDBText – use XMLText

Using the Java DOM API for XMLType

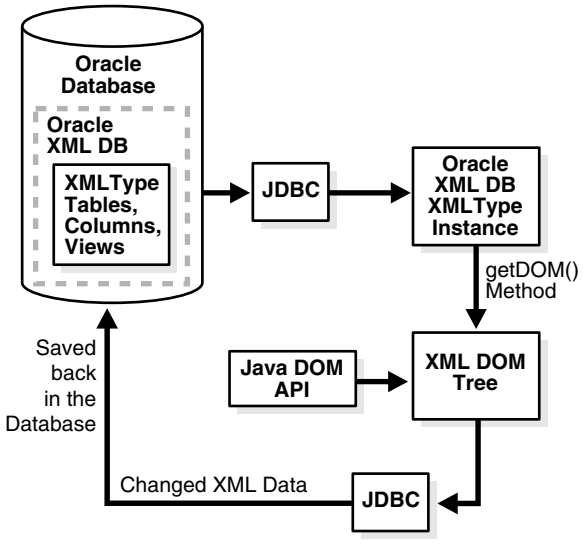
Figure 13–1 illustrates how to use the Java DOM API for XMLType.[1] These are the steps:

[1] This assumes that your XML data is pre-registered with an XML schema, and that it is stored in an XMLType column.

1. Retrieve the XML data from the `XMLType` table or `XMLType` column in the table. When you fetch XML data, Oracle creates an instance of an `XMLType`. You can then use method `getDocument()` to retrieve a Document instance. You can then manipulate elements in the DOM tree using Java DOM API for `XMLType`.
2. Use the Java DOM API for `XMLType` to manipulate elements of the DOM tree. The XMLType instance holds the modified data, but the data is sent back using a JDBC update.

The `XMLType` and `XMLDocument` instances should be closed using method `close()` in the respective classes. This frees any underlying memory that is held.

Figure 13–1 Using the Java DOM API for XMLType



Large XML Node Handling with Java

Prior to Oracle Database 11g Release 1 (11.1), there were restrictions on the size of nodes to less than 64 KB, because the Java methods to set and get a node value supported only arguments of type `java.lang.String`. The maximum size of a string is dependent on the implementation of the Java VM, but it is bounded. Prior to Release 11.1, the Java DOM APIs to manage a node value, contained within class `oracle.xdb.dom.XDBNode.java`, were these:

```
public String getNodeValue ();
public void setNodeValue (String value);
```

The Java DOM APIs to manage an attribute, contained within class `oracle.xdb.dom.XDBAttribute.java`, were these:

```
public String getValue ();
public void setValue (String value);
```

Package `oracle.xdb.dom` is deprecated, starting with Oracle Database 11g Release 1 (11.1). Java classes `XDBNode` and `XDBAttribute` in that package are replaced by classes `XMLNode` and `XMLAttr`, respectively, in package `oracle.xml.parser.v2`. In addition, these DOM APIs were extended in Release 11.1 to support text and binary node values of arbitrary size.

Note: The large-node feature works only with a thick or kprb connection. It does not work with a thin connection.

See Also:

- "Large Node Handling Using DBMS_XMLDOM" on page 11-14 for information on using PL/SQL with large nodes
- "Java Methods That Are Deprecated or Not Supported" on page 13-16 for more about deprecated classes `XDBNode` and `XDBAttribute`

Stream Extensions to Java DOM

All `Java String`, `Reader`, and `Writer` data is represented in `UCS2`, which might be different from the database character set. Additionally, node character data is tagged with a character set id, which is set at the time the node value is populated.

The following methods of `oracle.xml.parser.v2.XMLNode.java` can be used to access nodes of size greater than 64 KB. These APIs throw exceptions if you try to get or set a node that is not a leaf node (attribute, `PI`, `CDATA`, and so on). Also, be sure to use `close()` which actually writes the value and frees resources used to maintain the state for streaming access to nodes.

Get-Pull Model

For a binary input stream:

```
public java.io.InputStream getNodeValueAsBinaryStream ()
  throws java.io.IOException,
         DOMException;
```

Method `getNodeValueAsBinaryStream()` returns an instance of `java.io.InputStream` that can be read using the defined methods for this class. The data type of the node must be `RAW` or `BLOB`. If not, an `IOException` is thrown. The following example fragment illustrates reading the value of a node in binary 50-byte segments:

```
...
oracle.xml.parser.v2.XMLNode node = null;
...
java.io.InputStream value = node.getNodeValueAsBinaryStream ();
// now read InputStream...
byte buffer [] = new byte [50];
int returnValue = 0;
while ((returnValue = value.read (buffer)) != -1)
{
  // process next 50 bytes of node
}
...
```

For a character input stream:

```
public java.io.Reader getNodeValueAsCharacterStream()
  throws java.io.IOException,
         DOMException;
```

Method `getNodeValueAsCharacterStream()` returns an instance of `java.io.Reader` that can be read using the defined methods for this class. If the data type of the node is neither character nor `CLOB`, the node data is first converted to character. All node data

is ultimately in character format and is converted to UCS2, if necessary. The following example fragment illustrates reading the node value in segments of 50 characters:

```
...
oracle.xml.parser.v2.XMLNode node = null;
...
java.io.Reader value = node.getNodeValueAsCharacterStream ();
// now read InputStream
char buffer [] = new char [50];
int returnValue = 0;
while ((returnValue = value.read (buffer)) != -1)
{
  // process next 50 characters of node
}
...
```

Get-Push Model

For a binary output stream:

```
public void getNodeValueAsBinaryStream (java.io.OutputStream pushValue)
  throws java.io.IOException,
         DOMException;
```

The state of the java.io.OutputStream specified by pushValue must be open. The data type of the node must be RAW or BLOB. If not, an IOException is thrown. The node binary data is written to pushValue using method write() of OutputStream, and method close() is called when the node value has been completely written to the stream.

For a character output stream:

```
public void getNodeValueAsCharacterStream (java.io.Writer pushValue)
  throws java.io.IOException,
         DOMException;
```

The state of the java.io.Writer specified by pushValue must be open. If the data type of the node is neither character nor CLOB, then the data is first converted to character. The node data, always in character format, is converted, as necessary, to UCS2 and then pushed into the java.io.Writer.

Set-Pull Model

For a binary input stream:

```
public void setNodeValueAsBinaryStream (java.io.InputStream pullValue)
  throws java.io.IOException,
         DOMException;
```

The state of the java.io.InputStream specified by pullValue must be open. The data type of the node must be RAW or BLOB. If not, an IOException is thrown. The binary data from pullValue is read in its entirety using method read() of InputStream and replaces the node value.

```
import java.io.InputStream;
import oracle.xml.parser.*;
...
oracle.xml.parser.v2.XMLNode node = null;
...
byte [] buffer = new byte [500];
java.io.InputStream  istream; //user-defined input stream
node.setNodeValueAsBinaryStream (istream);
```

For a character input stream:

```
public void setNodeValueAsCharacterStream (java.io.Reader pullValue)
  throws java.io.IOException,
         DOMException;
```

The state of the `java.io.Reader` specified by `pullValue` must be open. If the data type of the node is neither character nor `CLOB`, the character data is converted from `UCS2` to the node data type. If the data type of the node is character or `CLOB`, then the character data read from `pullValue` is converted from `UCS2` to the character set of the node.

Set-Push Model

For a binary output stream:

```
public java.io.OutputStream setNodeValueAsBinaryStream ()
  throws java.io.IOException,
         DOMException;
```

Method `setNodeValueAsBinaryStream()` returns an instance of `java.io.OutputStream`, into which the caller can write the node value. The data type of the node must be `RAW` or `BLOB`. Otherwise, an `IOException` is raised. The following example fragment illustrates setting the value of a node to binary data by writing to the implementation of `java.io.OutputStream` provided by Oracle XML DB or Oracle XML Developer's Kit.

For a character output stream:

```
public java.io.Writer setNodeValueAsCharacterStream ()
  throws java.io.IOException,
         DOMException;
```

Method `setNodeValueAsCharacterStream()` returns an instance of `java.io.Writer` into which the caller can write the node value. The character data written is first converted from `UCS2` to the node character set, if necessary. If the data type of the node is neither character nor `CLOB`, then the character data is converted to the node data type. Similarly, the following example fragment illustrates setting the value of a node to character data by writing to the implementation of `java.io.Writer` provided by Oracle XML DB or Oracle XML Developer's Kit.

```
import java.io.Writer;
import oracle.xml.parser.*;
...
oracle.xml.parser.v2.XMLNode node = null;
...
char [] buffer = new char [500];
java.io.Writer  writer = node.setNodeValueAsCharacterStream ();
for (int k = 0; k < 10; k++)
{
  byte segment [] = new byte [50];
  // copy next subset of buffer into segment
  writer.write (segment);
}
writer.flush ();
writer.close();
```

See Also:

- *Oracle Database XML Java API Reference*
- *Oracle Database XML C API Reference* for information about C functions for large nodes

Oracle XML DB creates a `writer` or `OutputStream` and passes it to the user who calls method `write()` repeatedly until the complete node value has been written. The new node value is reflected only when the user calls method `close()`.

Using the Java DOM API and JDBC with Binary XML

XML data can be stored in Oracle XML DB using `XMLType`, and one of the storage models for this abstract data type is binary XML, a compact, XML Schema-aware encoding of XML data. You can use binary XML as a storage model for `XMLType` in the database, but you can also use it for XML data located outside the database. Client-side processing of XML data can involve data stored in Oracle XML DB or transient data that resides outside the database.

You can use the Java DOM API for XML to read or write XML data that is encoded as binary XML from or to Oracle XML DB. Doing so involves the usual read and write procedures.

Binary XML is XML Schema-aware and can use various encoding schemes, depending on your needs and your data. Because of this, in order to manipulate binary XML data, you must have both the data and this metadata about the relevant XML schemas and encodings.

For `XMLType` data stored in the database, this metadata is also stored in the database. However, depending on how your database and data are set up, the metadata might not be on the same server as the data it applies to. If this is the case, then, before you can read or write binary XML data from or to the database, you must carry out these steps:

1. Create a context instance for the metadata.
2. Associate this context with a data connection that you use to access binary XML data in the database. A data connection can be a dedicated connection or a connection pool. You use methods `getDedicatedConn()` and `getConnPool()` in class `java.sql.Connection` to obtain handles to these two types of connection, respectively.

Then, when your application needs to encode or decode binary XML data on the data connection, it automatically fetches the metadata needed for that. The overall sequence of actions is thus as follows:

1. Create an XML data connection object, in class `java.sql.Connection`.
2. Create one or more metadata contexts, as needed, using method `BinXMLMetadataProviderFactory.createDBMetadataProvider()` in package `oracle.xml.binxml`. A metadata context is sometimes referred to as a metadata repository. You can create a metadata context from a dedicated connection or from a connection pool.
3. Associate the metadata context(s) with the binary XML data connection(s). Use method `DBBinXMLMetadataProvider.associateDataConnection()` in package `oracle.xml.binxml` to do this.
4. (Optional) If the XML data originated outside of the database, use method `oracle.xdb.XMLType.setFormatPref()` to specify that XML data to be sent to the

database be encoded in the binary XML format. This applies to a DOM document (class `oracle.xdb.XMLType`). If you do not specify binary XML, the data is sent to the database as text.

5. Use the usual Java methods to read and write XML data from and to the database. Whenever it is needed for encoding or decoding binary XML documents, the necessary metadata is fetched automatically using the metadata context.

   Use the Java DOM API for XML to operate on the XML data at the client level.

Example 13–15 illustrates this.

Example 13–15 Using the Java DOM API with Binary XML

```
import java.sql.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.OracleDataSource;
import oracle.xdb.XMLType;
import oracle.xml.binxml.*;
class tdadxdbxdb11jav001
{
  public static void printBinXML() throws SQLException, BinXMLException
  {
    // Create datasource to connect to local database
    OracleDataSource ods = new OracleDataSource();
    ods.setURL("jdbc:oracle:kprb");
    System.out.println("Starting Binary XML Java Example");
    // Create data connection
    Connection conn = ods.getConnection();
    // Create binary XML metadata context, using connection pool
    DBBinXMLMetadataProvider repos =
      BinXMLMetadataProviderFactory.createDBMetadataProvider();
    repos.setConnectionPool(ods);
    // Associate metadata context with data connection
    repos.associateDataConnection(conn);
    // Query XML data stored in XMLType column as binary XML
    Statement stmt = conn.createStatement();
    ResultSet rset = stmt.executeQuery("SELECT doc FROM po_binxmltab");
    // Get the XMLType object
    while (rset.next())
    {
      XMLType xmlobj = (XMLType) rset.getObject(1);
      // Perform XMLType operation
      String xmlvalue = xmlobj.getStringVal();
      System.out.println(xmlvalue);
    }
    // Close result set, statement, and connection
    rset.close();
    stmt.close();
    conn.close();
    System.out.println("Completed Binary XML Java Example");
  }
}
```

See Also:

- "XMLType Storage Models" on page 1-11
- *Oracle XML Developer's Kit Programmer's Guide*

14

The C API for XML

This chapter provides help for using the C API for XML with Oracle XML DB. It contains these topics:

Overview of the C API for XML

The C API for XML is used for both Oracle XML Developer's Kit (XDK) and Oracle XML DB. It is a C-based DOM[1] API for XML. It can be used for XML data that is inside or outside the database. This API also includes performance-improving extensions that you can use in XDK for traditional storage of XML data, or in Oracle XML DB for storage as an `XMLType` column in a table.

> **Note:** C DOM functions from releases prior to Oracle Database 10*g* Release 1 are supported only for backward compatibility.

The C API for XML is implemented on `XMLType` in Oracle XML DB. In the W3C DOM Recommendation, the term "document" is used in a broad sense (URI, file system, memory buffer, standard input and output).

The C API for XML is a combined programming interface that includes all of the functionality needed by Oracle XML Developer's Kit and Oracle XML DB applications. It provides XSLT and XML Schema implementations. Although the DOM 2.0 Recommendation was followed closely, some naming changes were required for mapping from the objected-oriented DOM 2.0 Recommendation to the flat C namespace. For example, method `getName()` was renamed to `getAttrName()`.

[1] DOM refers to compliance with the World Wide Web Consortium (W3C) DOM 2.0 Recommendation.

The C API for XML supersedes older Oracle APIs. In particular, the `oraxml` interface (top-level, DOM, SAX, and XSLT) and `oraxsd.h` (Schema) interfaces will be deprecated in a future release.

The reference documentation for the C and C++ Application Programming Interfaces (APIs) that you can use to manipulate XML data is *Oracle Database XML C API Reference*, and *Oracle Database XML C++ API Reference*.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL APIs for XML
- *Oracle Database XML Java API Reference* for information about Java APIs for XML

OCI and the C API for XML: Use with Oracle XML DB

OCI applications typically operate on XML data stored in the server or created on the client. This section explains these two access methods in more detail.

Accessing XMLType Data Stored in the Database

Oracle XML DB provides support for storing and manipulating XML instances using abstract data type `XMLType`. These XML instances can be accessed and manipulated on the client side using the Oracle Call Interface (OCI) in conjunction with the C DOM API for XML. You can bind and define `XMLType` values using the C DOM structure `xmldocnode`. This structure can be used for binding, defining and operating on XML values in OCI statements. You can use OCI statements to select XML data from the server, which you can then use with C DOM API functions. Similarly, values can be bound back to SQL statements directly.

The main flow for an application program involves initializing the usual OCI handles, such as server handle and statement handle, and then initializing an XML context parameter. You can then either operate on XML instances in the database or create new instances on the client side. The initialized XML context can be used with all of the C DOM functions.

See Also: "XML Context Parameter for C DOM API Functions" on page 14-3

Creating XMLType Instances on the Client

You can construct new `XMLType` instances on the client side using `XmlLoadDom()`, as follows:

1. Initialize the `xmlctx` as in Example 14–1.
2. Construct the XML data from a user buffer, local file, or URI. The return value, a (`xmldocnode*`), can be used in the rest of the common C API.
3. If required, you can cast (`xmldocnode *`) to (`void*`) and provide it directly as the bind value.

You can construct empty `XMLType` instances with `XMLCreateDocument()`. This is similar to using `OCIObjectNew()` for other types.

XML Context Parameter for C DOM API Functions

An *XML context* is a required parameter to all the C DOM API functions. This opaque context encapsulates information about the data encoding, the error message language, and so on. The contents of the context are different for Oracle XML Developer's Kit applications and Oracle XML DB. For Oracle XML DB, there are two OCI functions that initialize (`OCIXmlDbInitXmlCtx()`) and terminate (`OCIXmlDbFreeXmlCtx()`) an XML context.

OCIXmlDbInitXmlCtx() Syntax

The syntax of function `OCIXmlDbInitXmlCtx()` is as follows:

```
xmlctx *OCIXmlDbInitXMlCtx (OCIEnv        *envhp,
                            OCISvcHp      *svchp,
                            OCIError      *errhp,
                            ocixmldbparam *params,
                            ub4           num_params);
```

Table 14–1 describes the parameters.

Table 14–1 OCIXmlDbInitXMlCtx() Parameters

Parameter	Description
`envhp (IN)`	The OCI environment handle.
`svchp (IN)`	The OCI service handle.
`errhp (IN)`	The OCI error handle.
`params (IN)`	An array of optional values: ▪ OCI duration. Default value is `OCI_DURATION_SESSION`. ▪ Error handler, which is a user-registered callback: `void (*err_handler) (sword errcode, (CONST OraText *) errmsg);`
`num_params (IN)`	Number of parameters to be read from `params`.

OCIXmlDbFreeXmlCtx() Syntax

The syntax of function `OCIXmlDbFreeXmlCtx()` is as follows, where parameter `xctx (IN)` is the XML context to terminate.:

```
void OCIXmlDbFreeXmlCtx (xmlctx *xctx);
```

Initializing and Terminating an XML Context

Example 14–1 shows a C program that uses the C DOM API to construct an XML document and save it to Oracle Database in table `my_table`. It calls OCI functions `OCIXmlDbInitXmlCtx()` and `OCIXmlDbFreeXmlCtx()` to initialize and terminate the XML context. These OCI functions are defined in header file `ocixmldb.h`.

The C code in Example 14–1 assumes that the following SQL code has first been executed to create table `my_table` in database schema `capiuser`:

```
CONNECT CAPIUSER
Enter password: password

Connected.
```

```
CREATE TABLE my_table OF XMLType;
```

Example 14–1 shows how to use OCI functions `OCIXmlDbInitXmlCtx()` and `OCIXmlDbFreeXmlCtx()` to initialize and terminate the XML context.

Example 14–1 Using OCIXMLDBINITXMLCTX() and OCIXMLDBFREEXMLCTX()

```
#ifndef S_ORACLE
#endif
#ifndef ORATYPES_ORACLE
#include <oratypes.h>
#endif
#ifndef XML_ORACLE
#include <xml.h>
#endif
#ifndef OCIXML_ORACLE
#include <ocixml.h>
#endif
#ifndef OCI_ORACLE
#include <oci.h>
#endif
#include <string.h>

typedef struct test_ctx {
        OCIEnv *envhp;
        OCIError *errhp;
        OCISvcCtx *svchp;
        OCIStmt *stmthp;
        OCIServer *srvhp;
        OCIDuration dur;
        OCISession *sesshp;
        oratext *username;
        oratext *password;
} test_ctx;

/* Helper function 1: execute a sql statement which binds xml data */
static sword exec_bind_xml(OCISvcCtx *svchp,
                           OCIError *errhp,
                           OCIStmt *stmthp,
                           void *xml,
                           OCIType *xmltdo,
                           OraText *sqlstmt);

/* Helper function 2: Initialize OCI handles and connect */
static sword init_oci_handles(test_ctx *ctx);

/* Helper function 3: Free OCI handles and disconnect */
static sword free_oci_handles(test_ctx *ctx);

void main()
{
  test_ctx temp_ctx;
  test_ctx *ctx = &temp_ctx;
  OCIType *xmltdo = (OCIType *) 0;
  xmldocnode *doc = (xmldocnode *)0;
  ocixmldbparam params[1];
  xmlnode *quux, *foo, *foo_data, *top;
  xmlerr err;
  sword status = 0;
  xmlctx *xctx;
```

```
oratext ins_stmt[] = "insert into my_table values (:1)";
oratext tlpxml_test_sch[] = "<TOP/>";
ctx->username = (oratext *)"capiuser";
ctx->password = (oratext *)"***********"; /* Replace with real password */

/* Initialize envhp, svchp, errhp, dur, stmthp */
init_oci_handles(ctx);

/* Get an xml context */
params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
params[0].value_ocixmldbparam = &ctx->dur;
xctx = OCIXmlDbInitXmlCtx(ctx->envhp, ctx->svchp, ctx->errhp, params, 1);

/* Start processing - first, check that this DOM supports XML 1.0 */
printf("\n\nSupports XML 1.0? : %s\n",
       XmlHasFeature(xctx, (oratext *) "xml", (oratext *) "1.0") ?
       "YES" : "NO");

/* Parse a document */
if (!(doc = XmlLoadDom(xctx, &err, "buffer", tlpxml_test_sch,
                       "buffer_length", sizeof(tlpxml_test_sch)-1,
                       "validate", TRUE, NULL)))
{
  printf("Parse failed, code %d\n", err);
}
else
{
  /* Get the document element */
  top = (xmlnode *)XmlDomGetDocElem(xctx, doc);

  /* Print out the top element */
  printf("\n\nOriginal top element is :\n");
  XmlSaveDom(xctx, &err, top, "stdio", stdout, NULL);

  /* Print out the document-note that the changes are reflected here */
  printf("\n\nOriginal document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "stdio", stdout, NULL);

  /* Create some elements and add them to the document */
  quux = (xmlnode *) XmlDomCreateElem(xctx ,doc, (oratext *) "QUUX");
  foo = (xmlnode *) XmlDomCreateElem(xctx, doc, (oratext *) "FOO");
  foo_data = (xmlnode *) XmlDomCreateText(xctx, doc, (oratext *) "data");
  foo_data = XmlDomAppendChild(xctx, (xmlnode *) foo, (xmlnode *) foo_data);
  foo = XmlDomAppendChild(xctx, quux, foo);
  quux = XmlDomAppendChild(xctx, top, quux);

  /* Print out the top element */
  printf("\n\nNow the top element is :\n");
  XmlSaveDom(xctx, &err, top, "stdio", stdout, NULL);

  /* Print out the document. Note that the changes are reflected here */
  printf("\n\nNow the document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "stdio", stdout, NULL);

  /* Insert the document into my_table */
  status = OCITypeByName(ctx->envhp, ctx->errhp, ctx->svchp,
                         (const text *) "SYS", (ub4) strlen((char *)"SYS"),
                         (const text *) "XMLTYPE",
                         (ub4) strlen((char *)"XMLTYPE"), (CONST text *) 0,
```

```
                          (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                          (OCIType **) &xmltdo);
    if (status == OCI_SUCCESS)
    {
      exec_bind_xml(ctx->svchp, ctx->errhp, ctx->stmthp, (void *)doc, xmltdo,
                    ins_stmt);
    }
  }
  /* Free xml ctx */
  OCIXmlDbFreeXmlCtx(xctx);

  /* Free envhp, svchp, errhp, stmthp */
  free_oci_handles(ctx);
}
```

The output from compiling and running this C program is as follows:

```
Supports XML 1.0? : YES

Original top element is :
<TOP/>

Original document is :
<TOP/>

Now the top element is :
<TOP>
  <QUUX>
    <FOO>data</FOO>
  </QUUX>
</TOP>

Now the document is :
<TOP>
  <QUUX>
    <FOO>data</FOO>
  </QUUX>
</TOP>
```

This is the result of querying the constructed document in `my_table`:

```
SELECT * FROM my_table;

SYS_NC_ROWINFO$
---------------
<TOP>
  <QUUX>
    <FOO>data</FOO>
  </QUUX>
</TOP>

1 row selected.
```

Example 14–1 constructs an XML document using the C DOM API and saves it to the database. The code uses helper functions `exec_bind_xml`, `init_oci_handles`, and `free_oci_handles`, which are not listed here. The complete listing of this example, including the helper functions, can be found in Appendix A, "Oracle-Supplied XML Schemas and Examples", "Initializing and Terminating an XML Context (OCI)" on page A-50.

Example 14–4 queries table `my_table` to show the data that was inserted by Example 14–1.

Using the C API for XML with Binary XML

XML data can be stored in Oracle XML DB using `XMLType`, and one of the storage models for this abstract data type is binary XML. Binary XML is a compact, XML Schema-aware encoding of XML data. You can use it as a storage model for `XMLType` in the database, but you can also use it for XML data located outside the database. As explained in "OCI and the C API for XML: Use with Oracle XML DB" on page 14-2, client-side processing of XML data can involve data stored in Oracle XML DB or transient data that resides outside the database.

You can use the C API for XML to read or write XML data that is encoded as binary XML from or to Oracle XML DB. Doing so involves the usual read and write procedures.

Binary XML is XML Schema-aware and can use various encoding schemes, depending on your needs and your data. Because of this, in order to manipulate binary XML data, you must have both the data and this metadata about the relevant XML schemas and encodings.

For `XMLType` data stored in the database, this metadata is also stored in the database. However, depending on how your database and data are set up, the metadata might not be on the same server as the data it applies to. If this is the case, then, before you can read or write binary XML data from or to the database, you must carry out these steps:

1. Create a context instance for the metadata.
2. Associate this context with a data connection that you use to access binary XML data in the database. A data connection can be a dedicated connection (`OCISvcCtx`) or a connection pool (`OCICPool`).

Then, when your application needs to encode or decode binary XML data on the data connection, it automatically fetches the metadata needed for that. The overall sequence of actions is thus as follows:

1. Create the usual OCI handles for environment (`OCIEnv`), connection (`OCISvcCtx`), and error context (`OCIError`).
2. Create one or more metadata contexts, as needed. A metadata context is sometimes referred to as a metadata repository, and `OCIBinXMLReposCtx` is the OCI context data structure.

   You use `OCIBinXMLCreateReposCtxFromConn` to create a metadata context from a dedicated connection and `OCIBinXMLCreateReposCtxFromCPool` to create a context from a connection pool.
3. Associate the metadata context(s) with the binary XML data connection(s). You use `OCIBinXmlSetReposCtxForConn` to do this.
4. (Optional) If the XML data originated outside of the database, use `setPicklePreference` to specify that XML data to be sent to the database from now on is in binary XML format. This applies to a DOM document (`xmldomdoc`). If you do not specify binary XML, the data is stored as text (`CLOB`).
5. Use OCI libraries to read and write XML data from and to the database. Whenever it is needed for encoding or decoding binary XML documents, the necessary metadata is fetched automatically using the metadata context.

Use the C DOM API for XML to operate on the XML data at the client level. Example 14–2 illustrates this.

Example 14–2 Using the C API for XML with Binary XML

```
. . .
/* Private types and constants */
#define SCHEMA        (OraText *)"SYS"
#define TYPE          (OraText *)"XMLTYPE"
#define USER          (OraText *)"oe"
#define USER_LEN      (ub2)(strlen((char *)USER))
#define PWD           (OraText *)"oe"
#define PWD_LEN       (ub2)(strlen((char *)PWD))
#define NUM_PARAMS    1
static void checkerr(OCIError *errhp, sword status);
static sword create_env(OraText *user, ub2 user_len, OraText *pwd, ub2 pwd_len,
                        OCIEnv **envhp, OCISvcCtx **svchp, OCIError **errhp);
static sword run_example(OCIEnv *envhp, OCISvcCtx *svchp, OCIError *errhp,
                         OCIDuration dur);
static void cleanup(OCIEnv *envhp, OCISvcCtx *svchp, OCIError *errhp);

int main (int argc, char *argv[])
{
  OCIEnv     *envhp;
  OCISvcCtx  *svchp;
  OCIError   *errhp;
  printf("*** Starting Binary XML Example program\n");
  if (create_env(USER, USER_LEN, PWD, PWD_LEN, &envhp, &svchp, &errhp))
    {
      printf("FAILED: create_env()\n");
      cleanup(envhp, svchp, errhp);
      return OCI_ERROR;
    }
  if (run_example(envhp, svchp, errhp, OCI_DURATION_SESSION))
    {
      printf("FAILED: run_example()\n");
      cleanup(envhp, svchp, errhp);
      return OCI_ERROR;
    }
  cleanup(envhp, svchp, errhp);
  printf ("*** Completed Binary XML example\n");
  return OCI_SUCCESS;
}

static sword create_env(OraText *user, ub2 user_len,
                        OraText *pwd,  ub2 pwd_len,
                        OCIEnv **envhp, OCISvcCtx **svchp, OCIError **errhp)
{
  sword       status;
  OCIServer  *srvhp;
  OCISession *usrp;
  OCICPool   *poolhp;
  OraText    *poolname;
  ub4         poolnamelen;
  OraText    *database =(OraText *)"";
  OCIBinXmlReposCtx *rctx;
  /* Create and initialize environment. Allocate error handle. */
  . . .
  if ((status = OCIConnectionPoolCreate((dvoid *)*envhp, (dvoid*)*errhp,
                                        (dvoid *)poolhp, &poolname,
```

```
                                        (sb4 *)&poolnamelen,
                                        (OraText *)0,
                                        (sb4) 0, 1, 10, 1,
                                        (OraText *)USER,
                                        (sb4) USER_LEN,
                                        (OraText *)PWD,
                                        (sb4) PWD_LEN,
                                        OCI_DEFAULT)) != OCI_SUCCESS)
    {
      printf ("OCIConnectionPoolCreate - Fail %d\n", status);
      return OCI_ERROR;
    }
  status = OCILogon2((OCIEnv *)*envhp, *errhp, svchp, (OraText *)USER,
                     (ub4)USER_LEN, (const oratext *)PWD, (ub4)PWD_LEN,
                     (const oratext *)poolname, poolnamelen, OCI_CPOOL);
  if (status)
    {
      printf ("OCILogon2 - Fail %d\n", status);
      return OCI_ERROR;
    }
  OCIBinXmlCreateReposCtxFromCPool(*envhp, poolhp, *errhp, &rctx);
  OCIBinXmlSetReposCtxForConn(*svchp, rctx);
  return OCI_SUCCESS;
}

static sword run_example(OCIEnv *envhp, OCISvcCtx *svchp, OCIError *errhp,
                         OCIDuration dur)
{
  OCIType   *xmltdo = (OCIType *)0;
  OCIStmt   *stmthp;
  OCIDefine *defnp;
  xmldocnode *xmldoc = (xmldocnode *)0;
  ub4        xmlsize = 0;
  text      *selstmt = (text *)"SELECT doc FROM po_binxmltab";
  sword      status;
  struct xmlctx *xctx = (xmlctx *) 0;
  ocixmldbparam params[NUM_PARAMS];
  xmlerr xerr = (xmlerr) 0;
  /* Obtain type definition for XMLType. Allocate statement handle.
     Prepare SELECT statement. Define variable for XMLType. Execute statement. */
  . . .
  /* Construct xmlctx for using XML C API */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &dur;
  xctx = OCIXmlDbInitXmlCtx(envhp, svchp, errhp, params, NUM_PARAMS);
  /* Print result to local string */
  XmlSaveDom(xctx, &xerr, (xmlnode *)xmldoc, "stdio", stdout, NULL);
  /* Free instances */
  . . .
}
```

See Also:

- "XMLType Storage Models" on page 1-11
- *Oracle XML Developer's Kit Programmer's Guide*

Using the Oracle XML Developer's Kit Pull Parser with Oracle XML DB

You can use the Oracle XML Developer's Kit pull parser with `XMLType` instances in Oracle XML DB. When you use this parser, parsing is done on demand, so your application drives the parsing process. Your application accesses an XML document through a sequence of events, with start tags, end tags, and comments, just as in Simple API for XML (SAX) parsing. However, unlike the case of SAX parsing, where parsing events are handled by callbacks, in pull parsing your application calls methods to ask for (pull) events only when it needs them. This gives the application more control over XML processing. In particular, filtering is more flexible with the pull parser than with the SAX parser.

You can also use the Oracle XML Developer's Kit pull parser to perform stream-based XML Schema validation.

Example 14–3 shows how to use the Oracle XML DB pull parser with an `XMLType` instance. To use the pull parser, you also need static library `libxml10.a` on UNIX and Linux systems or `oraxml10.dll` on Microsoft Windows systems. You also need header file `xmlev.h`.

See Also:

- *Oracle XML Developer's Kit Programmer's Guide* for information about the Oracle XML Developer's Kit pull parser
- *Oracle XML Developer's Kit Programmer's Guide* for information on using the pull parser for stream-based validation

Example 14–3 Using the Oracle XML DB Pull Parser

```
#define MAXBUFLEN 64*1024
void main()
{
  test_ctx temp_ctx;
  test_ctx *ctx = &temp_ctx;
  OCIType *xmltdo = (OCIType *) 0;
  ocixmldbparam params[1];
  sword status = 0;
  xmlctx *xctx;
  OCIDefine *defnp = (OCIDefine *) 0;
  oratext sel_stmt[] =
    "SELECT XMLSerialize(DOCUMENT x.OBJECT_VALUE AS CLOB) FROM PURCHASEORDER x where rownum = 1";
  OCILobLocator *cob;
  ub4 amtp, nbytes;
  ub1 bufp[MAXBUFLEN];
  ctx->username = (oratext *)"oe";
  ctx->password = (oratext *)"**************";    /* Replace with real password */

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_handles(ctx);

  /* Get an xml context */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &ctx->dur;
  xctx = OCIXmlDbInitXmlCtx(ctx->envhp, ctx->svchp, ctx->errhp, params, 1);

  /* Start processing */
  printf("\n\nSupports XML 1.0? : %s\n",
         XmlHasFeature(xctx, (oratext *) "xml", (oratext *) "1.0") ?
         "YES" : "NO");
```

```
  /* Allocate the lob descriptor */
  status = OCIDescriptorAlloc((dvoid *) ctx->envhp, (dvoid **) &clob,
                       (ub4)OCI_DTYPE_LOB, (size_t) 0, (dvoid **) 0);
  if (status)
  {
    printf("OCIDescriptorAlloc Failed\n");
    goto error;
  }
  status = OCIStmtPrepare(ctx->stmthp, ctx->errhp,
                (CONST OraText *)sel_stmt, (ub4) strlen((char *)sel_stmt),
                (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT);
  if (status)
  {
    printf("OCIStmtPrepare Failed\n");
    goto error;
  }
  status = OCIDefineByPos(ctx->stmthp, &defnp, ctx->errhp, (ub4) 1,
                (dvoid *) &clob, (sb4) -1, (ub2 ) SQLT_CLOB,
                (dvoid *) 0, (ub2 *)0,
                (ub2 *)0, (ub4) OCI_DEFAULT);
  if (status)
  {
    printf("OCIDefineByPos Failed\n");
    goto error;
  }
  status = OCIStmtExecute(ctx->svchp, ctx->stmthp, ctx->errhp, (ub4) 1,
                         (ub4) 0, (CONST OCISnapshot*) 0, (OCISnapshot*) 0,
                         (ub4) OCI_DEFAULT);
  if (status)
  {
    printf("OCIStmtExecute Failed\n");
    goto error;
  }
  /* read the fetched value into a buffer */
  amtp = nbytes = MAXBUFLEN-1;
  status = OCILobRead(ctx->svchp, ctx->errhp, clob, &amtp,
                (ub4) 1, (dvoid *) bufp, (ub4) nbytes, (dvoid *)0,
                (sb4 (*)(dvoid *, CONST dvoid *, ub4, ub1)) 0,
                (ub2) 0, (ub1) SQLCS_IMPLICIT);
  if (status)
  {
    printf("OCILobRead Failed\n");
    goto error;
  }
  bufp[amtp] = '\0';
  if (amtp > 0)
  {
     printf("\n=> Query result of %s: \n%s\n", sel_stmt, bufp);
     /********** PULL PARSING *****************/
     status = pp_parse(xctx, bufp, amtp);
     if (status)
       printf("Pull Parsing failed\n");
  }
error:
  /* Free XML Ctx */
  OCIXmlDbFreeXmlCtx(xctx);

  /* Free envhp, svchp, errhp, stmthp */
  free_oci_handles(ctx);
}
```

```
#define ERRBUFLEN 256
sb4 pp_parse(xctx, buf, amt)
xmlctx  *xctx;
oratext *buf;
ub4     amt;
{
  xmlevctx *evctx;
  xmlerr   xerr = XMLERR_OK;
  oratext  message[ERRBUFLEN];
  oratext  *emsg = message;
  xmlerr   ecode;
  boolean  done, inattr = FALSE;
  xmlevtype event;

  /* Create an XML event context - Pull Parser Context */
  evctx = XmlEvCreatePPCtx(xctx, &xerr,
                           "expand_entities", FALSE,
                           "validate", TRUE,
                           "attr_events", TRUE,
                           "raw_buffer_len", 1024,
                           NULL);
 if (!evctx)
  {
    printf("FAILED: XmlEvCreatePPCtx: %d\n", xerr);
    return OCI_ERROR;
  }
  /* Load the document from input buffer */
  xerr = XmlEvLoadPPDoc(xctx, evctx, "buffer", buf, amt, "utf-8");
  if (xerr)
  {
    printf("FAILED: XmlEvLoadPPDoc: %d\n", xerr);
    return OCI_ERROR;
  }
  /* Process the events until END_DOCUMENT event or error */
  done = FALSE;
  while(!done)
  {
    event = XmlEvNext(evctx);
    switch(event)
    {
      case XML_EVENT_START_ELEMENT:
        printf("START ELEMENT: %s\n", XmlEvGetName0(evctx));
        break;
      case XML_EVENT_END_ELEMENT:
        printf("END ELEMENT: %s\n", XmlEvGetName0(evctx));
        break;
      case XML_EVENT_START_DOCUMENT:
        printf("START DOCUMENT\n");
        break;
      case XML_EVENT_END_DOCUMENT:
        printf("END DOCUMENT\n");
        done = TRUE;
        break;
      case XML_EVENT_START_ATTR:
        printf("START ATTRIBUTE: %s\n", XmlEvGetAttrName0(evctx, 0));
        inattr = TRUE;
        break;
      case XML_EVENT_END_ATTR:
        printf("END ATTRIBUTE: %s\n", XmlEvGetAttrName0(evctx, 0));
        inattr = FALSE;
```

```
        break;
      case XML_EVENT_CHARACTERS:
        if (inattr)
          printf("ATTR VALUE: %s\n", XmlEvGetText0(evctx));
        else
          printf("TEXT: %s\n", XmlEvGetText0(evctx));
        break;
      case XML_EVENT_ERROR:
      case XML_EVENT_FATAL_ERROR:
        done = TRUE;
        ecode = XmlEvGetError(evctx, &emsg);
        printf("ERROR: %d: %s\n", ecode, emsg);
        break;
    }
  }
  /* Destroy the event context */
  XmlEvDestroyPPCtx(xctx, evctx);
  return OCI_SUCCESS;
}
```

The output from compiling and running this C program is as follows:

```
=> Query result of XMLSerialize(DOCUMENT x.OBJECT_VALUE AS CLOB) FROM PURCHASEORDER x where rownum = 1:
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:noNamespaceSchemaLocation=
                 "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
  <Reference>AMCEWEN-20021009123336171PDT</Reference>
  <Actions>
    <Action>
      <User>KPARTNER</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Allan D. McEwen</Requestor>
  <User>AMCEWEN</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Allan D. McEwen</name>
    <address>Oracle Plaza
Twin Dolphin Drive
Redwood Shores
CA
94065
USA</address>
    <telephone>650 506 7700</telephone>
  </ShippingInstructions>
  <SpecialInstructions>Ground</SpecialInstructions>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>Salesman</Description>
      <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    . . .
  </LineItems>
</PurchaseOrder>

START DOCUMENT
START ELEMENT: PurchaseOrder
START ATTRIBUTE: xmlns:xsi
ATTR VALUE: http://www.w3.org/2001/XMLSchema-instance
END ATTRIBUTE: xmlns:xsi
START ATTRIBUTE: xsi:noNamespaceSchemaLocation
```

```
ATTR VALUE: http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd
END ATTRIBUTE: xsi:noNamespaceSchemaLocation
START ELEMENT: Reference
TEXT: AMCEWEN-20021009123336171PDT
END ELEMENT: Reference
START ELEMENT: Actions
START ELEMENT: Action
START ELEMENT: User
TEXT: KPARTNER
END ELEMENT: User
END ELEMENT: Action
END ELEMENT: Actions
START ELEMENT: Reject
END ELEMENT: Reject
START ELEMENT: Requestor
TEXT: Allan D. McEwen
END ELEMENT: Requestor
START ELEMENT: User
TEXT: AMCEWEN
END ELEMENT: User
START ELEMENT: CostCenter
TEXT: S30
END ELEMENT: CostCenter
START ELEMENT: ShippingInstructions
START ELEMENT: name
TEXT: Allan D. McEwen
END ELEMENT: name
START ELEMENT: address
TEXT: Oracle Plaza
Twin Dolphin Drive
Redwood Shores
CA
94065
USA
END ELEMENT: address
START ELEMENT: telephone
TEXT: 650 506 7700
END ELEMENT: telephone
END ELEMENT: ShippingInstructions
START ELEMENT: SpecialInstructions
TEXT: Ground
END ELEMENT: SpecialInstructions
START ELEMENT: LineItems
START ELEMENT: LineItem
START ATTRIBUTE: ItemNumber
ATTR VALUE: 1
END ATTRIBUTE: ItemNumber
START ELEMENT: Description
TEXT: Salesman
END ELEMENT: Description
START ELEMENT: Part
START ATTRIBUTE: Id
ATTR VALUE: 37429158920
END ATTRIBUTE: Id
START ATTRIBUTE: UnitPrice
ATTR VALUE: 39.95
END ATTRIBUTE: UnitPrice
START ATTRIBUTE: Quantity
ATTR VALUE: 2
END ATTRIBUTE: Quantity
```

```
END ELEMENT: Part
END ELEMENT: LineItem
. . .
END ELEMENT: LineItems
END ELEMENT: PurchaseOrder
END DOCUMENT
```

Common XMLType Operations in C

Table 14–2 provides the `XMLType` functional equivalent of common XML operations.

Table 14–2 Common XMLType Operations in C

Description	C API XMLType Function
Create empty `XMLType` instance	`XmlCreateDocument()`
Create from a source buffer	`XmlLoadDom()`
Extract an XPath expression	`XmlXPathEvalexpr()` and family
Transform using an XSLT stylesheet	`XmlXslProcess()` and family
Check if an XPath exists	`XmlXPathEvalexpr()` and family
Is document schema-based?	`XmlDomIsSchemaBased()`
Get schema information	`XmlDomGetSchema()`
Get document namespace	`XmlDomGetNodeURI()`
Validate using schema	`XmlSchemaValidate()`
Obtain DOM from `XMLType`	Cast `(void *)` to `(xmldocnode *)`
Obtain XMLType from DOM	Cast `(xmldocnode *)` to `(void *)`

> **See Also:** *Oracle XML Developer's Kit Programmer's Guide* "XML Parser for C"

Example 14–4 shows how to use the DOM to determine how many instances of a particular part have been ordered. The part in question has `Id` `37429158722`. See Appendix A, "Oracle-Supplied XML Schemas and Examples", Example A–6 on page A-51 for the definitions of helper functions `exec_bind_xml`, `free_oci_handles`, and `init_oci_handles`.

Example 14–4 Using the DOM to Count Ordered Parts

```
#ifndef S_ORACLE
#endif
#ifndef ORATYPES_ORACLE
#include <oratypes.h>
#endif
#ifndef XML_ORACLE
#include <xml.h>
#endif
#ifndef OCIXML_ORACLE
#include <ocixml.h>
#endif
#ifndef OCI_ORACLE
#include <oci.h>
#endif
#include <string.h>
```

```
typedef struct test_ctx {
        OCIEnv *envhp;
        OCIError *errhp;
        OCISvcCtx *svchp;
        OCIStmt *stmthp;
        OCIServer *srvhp;
        OCIDuration dur;
        OCISession *sesshp;
        oratext *username;
        oratext *password;
} test_ctx;

/* Helper function 1: execute a sql statement which binds xml data */
static sword exec_bind_xml(OCISvcCtx *svchp,
                           OCIError *errhp,
                           OCIStmt *stmthp,
                           void *xml,
                           OCIType *xmltdo,
                           OraText *sqlstmt);

/* Helper function 2: Initialize OCI handles and connect */
static sword init_oci_handles(test_ctx *ctx);

/* Helper function 3: Free OCI handles and disconnect */
static sword free_oci_handles(test_ctx *ctx);

void main()
{
  test_ctx temp_ctx;
  test_ctx *ctx = &temp_ctx;
  OCIType *xmltdo = (OCIType *) 0;
  xmldocnode *doc = (xmldocnode *)0;
  ocixmldbparam params[1];
  xmlnode *quux, *foo, *foo_data, *top;
  xmlerr err;
  sword status = 0;
  xmlctx *xctx;
  ub4 xmlsize = 0;
  OCIDefine *defnp = (OCIDefine *) 0;
  oratext sel_stmt[] = "SELECT SYS_NC_ROWINFO$ FROM PURCHASEORDER";
  xmlnodelist *litems = (xmlnodelist *)0;
  xmlnode *item = (xmlnode *)item;
  xmlnode *part;
  xmlnamedmap *attrs;
  xmlnode *id;
  xmlnode *qty;
  oratext *idval;
  oratext *qtyval;
  ub4 total_qty;
  int i;
  int numdocs;

  ctx->username = (oratext *)"oe";
  ctx->password = (oratext *)"************";   /* Replace with real password */

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_handles(ctx);

  /* Get an xml context */
```

```
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &ctx->dur;
  xctx = OCIXmlDbInitXmlCtx(ctx->envhp, ctx->svchp, ctx->errhp, params, 1);

  /* Start processing */
  printf("\n\n Supports XML 1.0? : %s\n",
         XmlHasFeature(xctx, (oratext *) "xml", (oratext *) "1.0") ?
         "YES" : "NO");

  /* Get the documents from the database using a select statement */
  status = OCITypeByName(ctx->envhp, ctx->errhp, ctx->svchp, (const text *) "SYS",
                         (ub4) strlen((char *)"SYS"), (const text *) "XMLTYPE",
                         (ub4) strlen((char *)"XMLTYPE"), (CONST text *) 0,
                         (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                         (OCIType **) &xmltdo);
  status = OCIStmtPrepare(ctx->stmthp, ctx->errhp,
                 (CONST OraText *)sel_stmt, (ub4) strlen((char *)sel_stmt),
                 (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT);
  status = OCIDefineByPos(ctx->stmthp, &defnp, ctx->errhp, (ub4) 1, (dvoid *) 0,
                 (sb4) 0, SQLT_NTY, (dvoid *) 0, (ub2 *)0,
                 (ub2 *)0, (ub4) OCI_DEFAULT);
  status = OCIDefineObject(defnp, ctx->errhp, (OCIType *) xmltdo,
                  (dvoid **) &doc,
                  &xmlsize, (dvoid **) 0, (ub4 *) 0);
  status = OCIStmtExecute(ctx->svchp, ctx->stmthp, ctx->errhp, (ub4) 0, (ub4) 0,
                 (CONST OCISnapshot*) 0, (OCISnapshot*) 0, (ub4) OCI_DEFAULT);

  /* Initialize variables */
  total_qty = 0;
  numdocs = 0;

  /* Loop through all the documents */
  while ((status = OCIStmtFetch2(ctx->stmthp, ctx->errhp, (ub4) 1, (ub4) OCI_
FETCH_NEXT,
                                 (ub4)1, (ub4) OCI_DEFAULT)) == 0)
  {
    numdocs++;

    /* Get all the LineItem elements */
    litems = XmlDomGetDocElemsByTag(xctx, doc, (oratext *)"LineItem");
    i = 0;

    /* Loop through all LineItems */
    while (item = XmlDomGetNodeListItem(xctx, litems, i))
    {
      /* Get the part */
      part = XmlDomGetLastChild(xctx, item);

      /* Get the attributes */
      attrs = XmlDomGetAttrs(xctx, (xmlelemnode *)part);

      /* Get the id attribute and its value */
      id = XmlDomGetNamedItem(xctx, attrs, (oratext *)"Id");
      idval = XmlDomGetNodeValue(xctx, id);

      /* Keep only parts with id 37429158722 */
      if (idval && (strlen((char *)idval) == 11 )
          && !strncmp((char *)idval, (char *)"37429158722", 11))
      {
        /* Get the quantity attribute and its value.*/
```

```
        qty = XmlDomGetNamedItem(xctx, attrs, (oratext *)"Quantity");
        qtyval = XmlDomGetNodeValue(xctx, qty);

        /* Add the quantity to total_qty */
        total_qty += atoi((char *)qtyval);
      }
      i++;
    }
    XmlFreeDocument(xctx, doc);
    doc = (xmldocnode *)0;
  }
  printf("Total quantity needed for part 37429158722 = %d\n", total_qty);
  printf("Number of documents in table PURCHASEORDER = %d\n", numdocs);

  /* Free Xml Ctx */
  OCIXmlDbFreeXmlCtx(xctx);

  /* Free envhp, svchp, errhp, stmthp */
  free_oci_handles(ctx);
}
```

The output from compiling and running this C program is as follows:

```
Supports XML 1.0? : YES
Total quantity needed for part 37429158722 = 42
Number of documents in table PURCHASEORDER = 132
```

15

Oracle XML DB and Oracle Data Provider for .NET

Oracle Data Provider for Microsoft .NET (ODP.NET) is an implementation of a data provider for Oracle Database. It uses Oracle native APIs to offer fast and reliable access to Oracle data and features from any .NET application. It also uses and inherits classes and interfaces available in the Microsoft .NET Framework Class Library. ODP.NET supports the following LOB data types natively with .NET: `BLOB`, `CLOB`, `NCLOB`, and `BFILE`.

This chapter describes how to use ODP.NET with Oracle XML DB. It contains these topics:

Oracle XML DB Support for ODP.NET XML

ODP.NET supports XML data natively in the database, through Oracle XML DB. ODP.NET support by Oracle XML DB includes the following features:

- Stores XML data natively in Oracle Database as `XMLType`.
- Accesses relational and object-relational data as XML data from Oracle Database to a Microsoft .NET environment, and processes the XML using Microsoft .NET framework.
- Saves changes to the database server using XML data.

For the .NET application developer, these features include the following:

- Enhancements to the `OracleCommand`, `OracleConnection`, and `OracleDataReader` classes. Provides the following XML-specific classes:
  - `OracleXmlType`
  - `OracleXmlStream`
  - `OracleXmlQueryProperties`
  - `OracleXmlSaveProperties`

ODP.NET Sample Code

Example 15–1 retrieves `XMLType` data from the database to .NET and outputs the results:

Example 15–1 Retrieve XMLType Data to .NET

```
//Create OracleCommand and query XMLType
OracleCommand xmlCmd = new OracleCommand();
poCmd.CommandText = "SELECT po FROM po_tab";
poCmd.Connection = conn;
// Execute OracleCommand and output XML results to an OracleDataReader
OracleDataReader poReader = poCmd.ExecuteReader();
// ODP.NET native XML data type object from Oracle XML DB
OracleXmlType poXml;
string str = ""; //read XML results
while (poReader.Read())
{
  // Return OracleXmlType object of the specified XmlType column
  poXml = poReader.GetOracleXmlType(0);
  // Concatenate output for all the records
  str = str + poXml.Value;
} //Output XML results to the screen
Console.WriteLine(str);
```

See Also: *Oracle Data Provider for .NET Developer's Guide for Microsoft Windows* for complete information about Oracle .NET support for Oracle XML DB.

Part V

XML Schema and Object-Relational XMLType

Part III of this manual covers the use of XML Schema and object-relational storage of `XMLType` data. It conChapter 17, "XML Schema Storage and Query: Basic"tains the following chapters:

- Chapter 16, "Choice of XMLType Storage and Indexing"
- Chapter 17, "XML Schema Storage and Query: Basic"
- Chapter 19, "XPath Rewrite for Object-Relational Storage"
- Chapter 18, "XML Schema Storage and Query: Object-Relational Storage"
- Chapter 20, "XML Schema Evolution"

16

Choice of XMLType Storage and Indexing

This chapter is about choosing an appropriate `XMLType` storage model and indexing approaches for a given use case. It contains the following topics:

Introduction to Choosing an XMLType Storage Model and Indexing Approaches

`XMLType` is an abstract data type that provides different storage and indexing models to best fit your data and your use of it. Because it is an abstract data type, your applications and database queries gain in flexibility: the same interface is available for all `XMLType` operations.

Different applications use XML data in different ways. Sometimes it is constructed from relational data sources, so it is relatively structured. Sometimes it is used for extraction, transformation, and loading (ETL) operations, in which case it is also quite structured. Sometimes it is used for free-form documents (unstructured or semi-structured) such as books and articles.

Retrieval approaches can also be different for different kinds of data. Data-centric use cases often involve a fixed set of queries, whereas document-centric use cases often involve arbitrary (ad-hoc) queries.

Because there is a broad spectrum of XML usage, there is no one-size-fits-all storage model that offers optimal performance and flexibility for every use case. Oracle XML DB offers two storage models for `XMLType`, and several indexing methods appropriate to these different storage models. You can tailor performance and functionality to best fit the kind of XML data you have and the ways you use it.

Therefore, one key decision to make is which `XMLType` storage model to use for which XML data. This chapter helps you choose the best storage option for a given use case.

`XMLType` tables and columns can be stored in the following ways:

- **Binary XML storage** – This is also referred to as **post-parse persistence**. It is the default storage model for Oracle XML DB. It is a post-parse, binary format designed specifically for XML data. Binary XML is compact and XML

schema-aware. The biggest advantage of Binary XML storage is *flexibility*: you can use it for XML schema-based documents or for documents that are not based on an XML schema. You can use it with an XML schema that allows for high data variability or that evolves considerably or unexpectedly. This storage model also provides efficient partial updating and streamable query evaluation.

- **Object-relational storage** – This is also referred to as **structured** storage and **object-based persistence**. This storage model represents an entity-relationship (ER) decomposition of the XML data. It provides the best performance for highly structured data with a known and more or less fixed set of queries. Query performance matches that of relational data, and updates can be performed in place.

Note: Starting with Oracle Database 12*c* Release 1 (12.1.0.1), the unstructured (`CLOB`) storage model for `XMLType` is *deprecated*. Use binary XML storage instead.

If you have exising `XMLType` data that is stored as `CLOB` data then consider moving it to binary XML storage format using Oracle GoldenGate. If document fidelity is important for a particular XML document then store a copy of it in a relational `CLOB` column.

Oracle XML DB supports the following kinds of indexes on `XMLType` data.

- B-tree functional indexes on object-relational storage
- XML search index on binary XML storage
- `XMLIndex` with structured and unstructured components on binary XML storage
- B-tree indexes on the secondary tables created automatically for `XMLIndex` (both structured and unstructured components) on binary XML storage

Different use cases call for different combinations of `XMLType` storage model and indexes.

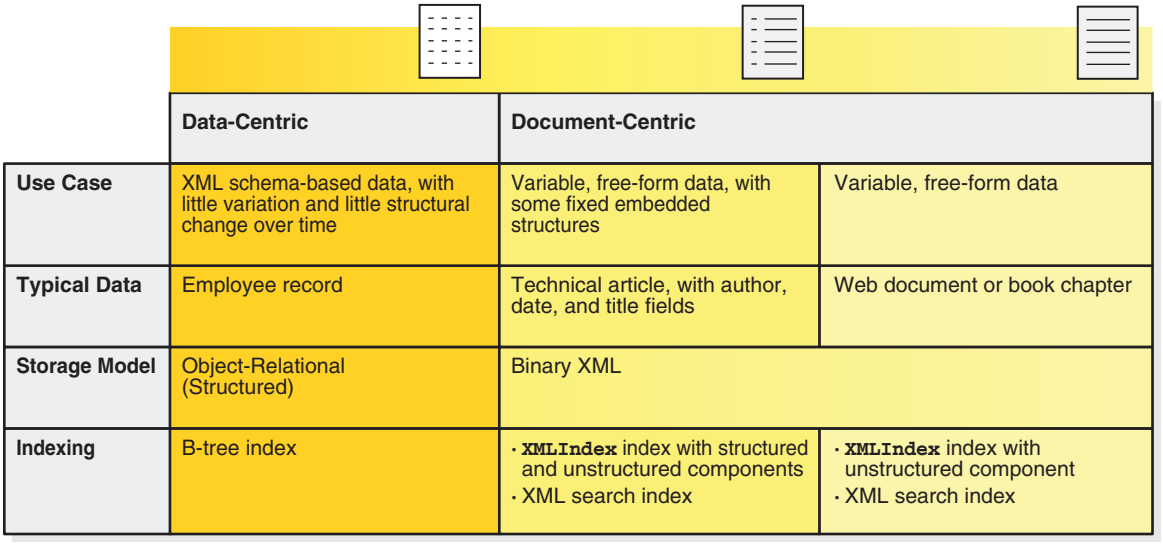
See Also:

- Chapter 6, "Indexes for XMLType Data"
- "XMLType Storage Options: Relative Advantages" on page 16-8

XMLType Use Case Spectrum: Data-Centric to Document-Centric

When choosing an `XMLType` storage model, consider the nature of your XML data and the ways you use it. Figure 16–1 shows a spectrum of use cases, from most data-centric, at the left, to most document-centric, at the right.

Figure 16–1 XML Use Cases and XMLType Storage Models



	Data-Centric	Document-Centric	
Use Case	XML schema-based data, with little variation and little structural change over time	Variable, free-form data, with some fixed embedded structures	Variable, free-form data
Typical Data	Employee record	Technical article, with author, date, and title fields	Web document or book chapter
Storage Model	Object-Relational (Structured)	Binary XML	
Indexing	B-tree index	· **`XMLIndex`** index with structured and unstructured components · XML search index	· **`XMLIndex`** index with unstructured component · XML search index

Data-centric data is highly structured, with relatively static and predictable structure, and your applications take advantage of this structure. The data conforms to an XML schema.

Document-centric data can be divided into two cases:

- The data is generally without structure or is of variable structure. This includes the case of documents that have both structured and unstructured parts. Document structure can vary over time (evolution), and the content can be **mixed** (**semi-structured**), with many elements containing both text nodes and child elements. Many XML elements can be absent or can appear in different orders. Documents might or might not conform to an XML schema.
- The data is relatively structured, but your applications do not take advantage of that structure: they treat the data as if it were without structure.

Common Use Cases for XML Data Stored as XMLType

This section presents the most common use cases for XML data stored as `XMLType`. If your use case is covered here then start by following the recommendations for it. If not, then refer to the rest of this chapter.

Note: This section is about the use of XML data that is persisted as `XMLType`. One common use case for XML data involves the generation of XML data from relational data. That case is not covered here, as it involves relational storage and the generated XML data is not necessarily persisted.

(For cases where generated XML data is persisted as `XMLType`, see "XMLType Use Case: Staged XML Data for ETL" on page 16-4.)

See Also: "Considerations for Choosing XMLType Storage Model and Indexing" on page 16-6

XMLType Use Case: No XML Fragment Updating or Querying

In this use case, there is no requirement to update or query fragments of XML data that is stored in the database. You have these options:

- Store it as `XMLType` using *binary XML storage*.
- Store it in a *relational* `BLOB` or `CLOB` column, preferably a SecureFiles LOB.

If you store the XML data in a relational LOB column, not as `XMLType`, Oracle Database does not parse the data and it cannot guarantee its validity. (And you cannot perform `XMLType` operations on the data.)

XMLType Use Case: Data Integration from Diverse Sources with Different XML Schemas

If your XML data comes from multiple data sources that use different XML schemas, then use *binary XML storage*.

This use case has three subcases:

- If the XML data contains islands of structured, predictable data, and your queries are known, then use `XMLIndex` with a *structured component* to index the structured islands (even if the data surrounding these islands is unstructured). A structured index component reflects the queries you use. An RSS news aggregator is an example of such a use case.
- If there are no such structured islands or your queries are unknown ahead of time (ad hoc) then use `XMLIndex` with an unstructured component.
- If you use queries that involve full-text search then use an XML search index, together with XQuery pragma `ora:no_schema`.

See Also:

- "XMLIndex Structured Component" on page 6-8
- "XMLIndex Unstructured Component" on page 6-12
- "Indexing XML Data for Full-Text Queries" on page 6-48 and "Oracle XQuery Extension-Expression Pragmas" on page 4-21

XMLType Use Case: Staged XML Data for ETL

In this use case, data is extracted from outside sources, transformed to fit operational needs (typically relational), and then loaded into the database: *extract*, *transform*, *load* (ETL). In particular, transformation distinguishes this use case.

ETL use cases often integrate data from multiple applications that are maintained or hosted by multiple parties using different software and hardware systems. The data that is extracted is often the responsibility of parties other than those who transform it or use it after transformation.

The XML data involved is typically highly structured and conforms to an XML schema. This use case covers both producing relational data from XML data and generating XML data from relational data.

A subset of ETL use cases involve the need to efficiently *update* the XML data. Updating can involve replacement of an entire XML document or changes to only fragments of a document (partial updating).

Object-relational storage of `XMLType` data is generally appropriate for this use case.

See Also:

- Chapter 9, "Relational Views over XML Data"
- Chapter 8, "Generation of XML Data from Relational Data"

XMLType Use Case: Semi-Structured XML Data

In this use case, either the XML data is of variable form or large portions of it are not well defined. There might not be an associated XML schema, or the XML schema might allow for high data variability or evolve considerably or in unexpected ways.

Binary XML storage of `XMLType` data is generally appropriate for this use case.

Use structured-component `XMLIndex` indexing when query paths are known, and use path-subsetted unstructured-component `XMLIndex` indexing when paths are not known beforehand (ad hoc queries). Use an XML search index for XQuery Full-Text queries.

See Also:

- "XMLIndex Structured Component" on page 6-8
- "XMLIndex Unstructured Component" on page 6-12
- "Indexing XML Data for Full-Text Queries" on page 6-48

XMLType Use Case: Business intelligence Queries

An analytic-function windowing clause, and SQL clauses `ORDER BY` and `GROUP BY`, enable business-intelligence (BI) queries over relational data. You can use SQL/XML function `XMLTable` to project values contained in XML data as columns of a virtual table. You can then use analytic-function windows, `ORDER BY`, and `GROUP BY` to operate on columns of the virtual table.

For business-intelligence queries, you will generally do all of the following:

- Store your `XMLType` data as binary XML.
- Use an `XMLIndex` index with a structured component.
- Create relational views over the data using SQL/XML function `XMLTable`, where the views project all columns of interest to the BI application.
- Write your application queries against these relational views.

If the `XMLIndex` index is created in one-to-one correspondence to these views, Oracle Database automatically translates queries over the views to queries over the relational tables of the structured `XMLIndex` component, providing relational performance.

When you use analytic-function windows, `ORDER BY`, or `GROUP BY` on a column of the virtual table, these operations are translated to windows, `ORDER BY`, and `GROUP BY` operations on the corresponding physical columns of the structured-component `XMLIndex` tables.

See Also:

- "XMLIndex Structured Component" on page 6-8
- Chapter 9, "Relational Views over XML Data"

XMLType Use Case: XML Queries Involving Full-Text Search

If your application needs to perform full-text searches on XML data then use *binary XML storage* and create XML search indexes that correspond to your queries.

See Also: "Indexing XML Data for Full-Text Queries" on page 6-48

Considerations for Choosing XMLType Storage Model and Indexing

This section presents things to consider when deciding on an `XMLType` storage model and an indexing approach, if your use case does not closely match one of those discussed in section "Common Use Cases for XML Data Stored as XMLType" on page 16-3.

XMLType Storage Model Considerations

For most use cases Oracle recommends that you use binary XML storage of `XMLType`. Object-relational storage is not appropriate unless *all* of the following are true:

- You have an XML schema that rigorously specifies the detailed data format of all XML documents that you intend to store in a given `XMLType` column or table. Your applications are data-centric.
- You do not expect your XML schema to evolve frequently in ways that do not allow in-place schema evolution.
- Your data is not especially sparse (does not include many elements that are empty or missing).
- You do not necessarily insert and select whole XML documents at a time. Partial updates and selections are common.
- You do not need document fidelity (DOM fidelity is sufficient).

Table 16–1 provides more detail about this. The guidelines it presents for choosing an `XMLType` storage model are *not* independent: follow them *in the order presented*, row by row, until a requirement in column **If...** is satisfied.

Table 16–1 XMLType Storage Model Considerations

If...	Then...
1. You need the property of document fidelity, preserving all original whitespace.	Use binary XML storage for database use and XML processing. But also store a copy of the original documents in a `CLOB` (relational) column. (It is your responsibility to keep the two versions synchronized, if you update the data.)
2. You rarely need to select or update only a portion of your XML data. Instead, you typically insert and select whole XML documents at a time.	Use binary XML storage.
3. You need to store `XMLType` instances that conform to different XML schemas in the *same* `XMLType` table or column. (Oracle does *not* recommend this practice in general, because it prohibits Oracle XML DB from using the XML schemas to optimize XML queries and other operations.)	Use binary XML storage.

Table 16–1 (Cont.) XMLType Storage Model Considerations

If...	Then...
4. You do *not* have an XML schema for your data.	Use binary XML storage. If you think that your data could benefit from XML schema validation, then consider also whether you can generate an XML schema for it using a schema-generation tool.
5. You expect your XML schema to evolve frequently or in unexpected ways, and you *cannot* take advantage of in-place XML schema evolution. In-place evolution is generally permitted only if the changes do not invalidate existing documents and they do not involve changing the storage model. See Chapter 20, "XML Schema Evolution".	Use binary XML storage. Use PL/SQL procedure `DBMS_XMLSCHEMA.copyEvolve` to update the XML schema.
6. Your XML data is very sparse.	Use binary XML storage.
7. Your XML schema does *not* make use of constructs such as elements `any` and `choice`, which do not provide a detailed specification of the data format. (XML schema generators often include such constructs in the generated schemas.)	Use object-relational storage.
8. You can modify your XML schema to remove constructs such as `any` and `choice` that prevent a rigorous definition of the structure of your XML data.	Remove such constructs, then use object-relational storage.
9. You cannot remove such constructs.	Use binary XML storage.

XMLType Indexing Considerations

For `XMLType` data stored object-relationally, create B-tree and bitmap indexes just as you would for relational data.

Use `XMLIndex` indexing with `XMLType` data that is stored as binary XML.

For general indexing of document-centric XML data, use `XMLIndex` with an *unstructured component*. This is appropriate for queries that are ad hoc (arbitrary).

For data that contains predictable, fixed parts that you query frequently, use `XMLIndex` with *structured components* for those parts. An example of this use case is a specification that is generally free-form but that has fixed fields for the author, date, and title.

To handle islands of structure within generally unstructured content, create an `XMLIndex` index that has both structured and unstructured components. A use case where you might use both components would be to support queries that extract an XML fragment from a document whenever some structured data is present. The structured component of the index would be used for a query `WHERE` clause condition that checks for the structured data. The unstructured component would be used for the fragment extraction.

Table 16–2 provides simple guidelines for indexing `XMLType` data that is stored as binary XML. These guidelines are *independent*: you can use a combination of indexing approaches if their **If...** conditions are satisfied.

Table 16–2 XMLType Indexing Considerations

If...	Then...
Your data contains predictable islands of structured data.	Use `XMLIndex`, with a structured component for each of the structured islands.
You need to support full-text queries.	Use XML search indexes.
You need to support ad-hoc XML queries involving predicates.	Use `XMLIndex`, with an unstructured component.

XMLType Storage Options: Relative Advantages

Table 16–3 summarizes the advantages and disadvantages of each `XMLType` storage model. Symbols + and – provide a rough indication of strength and weakness, respectively.

Table 16–3 XMLType Storage Models: Relative Advantages

Quality	Binary XML Storage	Object-Relational Storage
Throughput	(+) High throughput. Fast DOM loading. There is a slight overhead from the binary encoder/decoder.	(–) XML decomposition can result in reduced throughput when ingesting or retrieving the entire content of an XML document.
Indexing support	`XMLIndex` and XML search indexes.	B-tree, bitmap, and Oracle Text indexes on specific elements or attributes.
Queries	(+) Fast when using `XMLIndex`. Queries that cannot use an index use streaming XPath evaluation, which can also be fast.	(++) Relational query performance. You can create B-tree indexes on the underlying object-relational columns.
Update operations (DML)	(+) In-place, piecewise update for SecureFiles LOB storage.	(++) Relational update performance. Columns are updated in place.
Data flexibility	(+) Flexibility in the structure of the XML documents that can be stored in an `XMLType` column or table.	(–) Limited flexibility. Only documents that conform to the XML schema can be stored.
XML schema flexibility	(++) Both XML schema-based and non-schema-based documents can be stored. Documents conforming to any XML schemas that have been registered can be stored in the same `XMLType` table or column.	(–) Only documents that conform to the same XML schema can be stored in a given `XMLType` table or column.
Validation upon insert	(++) XML schema-based data can be fully validated when it is inserted, but this takes time.	(+) XML data is partially validated when it is inserted.
Compression and Encryption	(+) Binary XML with SecureFiles LOB storage can be compressed/encrypted.	(++) Each XML element/attribute can be compressed/encrypted individually.

17

XML Schema Storage and Query: Basic

The XML Schema Recommendation was created by the World Wide Web Consortium (W3C) to describe the content and structure of XML documents in XML. It includes the full capabilities of Document Type Definitions (DTDs) so that existing DTDs can be converted to XML Schema. XML schemas have additional capabilities compared to DTDs.

This chapter provides basic information about using XML Schema with Oracle XML DB. It explains how to do the following:

- Register, update, and delete an XML schema
- Create storage structures for XML schema-based data
- Map XML Schema data types to SQL data types

This chapter contains these topics:

See Also:

- Chapter 18, "XML Schema Storage and Query: Object-Relational Storage" for more advanced information about using XML Schema with Oracle XML DB
- Chapter 19, "XPath Rewrite for Object-Relational Storage" for information about the optimization of XPath expressions in Oracle XML DB
- `http://www.w3.org/TR/xmlschema-0/` for an introduction to XML Schema

Overview of XML Schema

The W3C XML Schema Recommendation defines a standardized language for specifying the structure, content, and certain semantics of a set of XML documents. An XML schema can be considered the metadata that describes a class of XML documents. The XML Schema Recommendation is described at:
`http://www.w3.org/TR/xmlschema-0/`

This manual refers to an XML Schema instance definition as an **XML schema** (lowercase).

XML Schema for Schemas

The W3C Schema working group publishes an XML schema, often referred to as the "Schema for Schemas". This XML schema provides the definition, or vocabulary, of the XML Schema language. All valid XML schemas can be considered to be members of the class defined by this XML schema. An XML schema is thus an XML document that conforms to the class defined by the XML schema published at `http://www.w3.org/2001/XMLSchema`.

XML Schema Features

The XML Schema language defines 47 scalar data types. This provides for strong typing of elements and attributes. The W3C XML Schema Recommendation also supports object-oriented techniques such as inheritance and extension, hence you can design XML schema with complex objects from base data types defined by the XML Schema language. The vocabulary includes constructs for defining and ordering, default values, mandatory content, nesting, repeated sets, and redefines. Oracle XML DB supports all the constructs, except for redefines.

XML Instance Documents

Documents conforming to a given XML schema can be considered as members or instances of the class defined by that XML schema. Consequently the term **instance document** is often used to describe an XML document that conforms to a given XML schema. The most common use of an XML schema is to validate that a given instance document conforms to the rules defined by the XML schema.

XML Namespaces and XML Schemas

An XML schema can optionally specify a `targetNamespace` attribute, whose value is a URL. If this attribute is omitted then the XML schema has no target namespace. The target namespace is the namespace for everything defined in the XML schema. It is common to use the URL where the XML schema can be accessed as the `targetNamespace` value.

An XML instance document must specify the namespace of the root element of the document (same as the target namespace of the XML schema that the instance conforms to) and the location (URL) of the XML schema that defines this root element. This information is specified by attribute `xsi:schemaLocation`. When the XML schema has no target namespace, use attribute `xsi:noNamespaceSchemaLocation` to specify the schema URL.

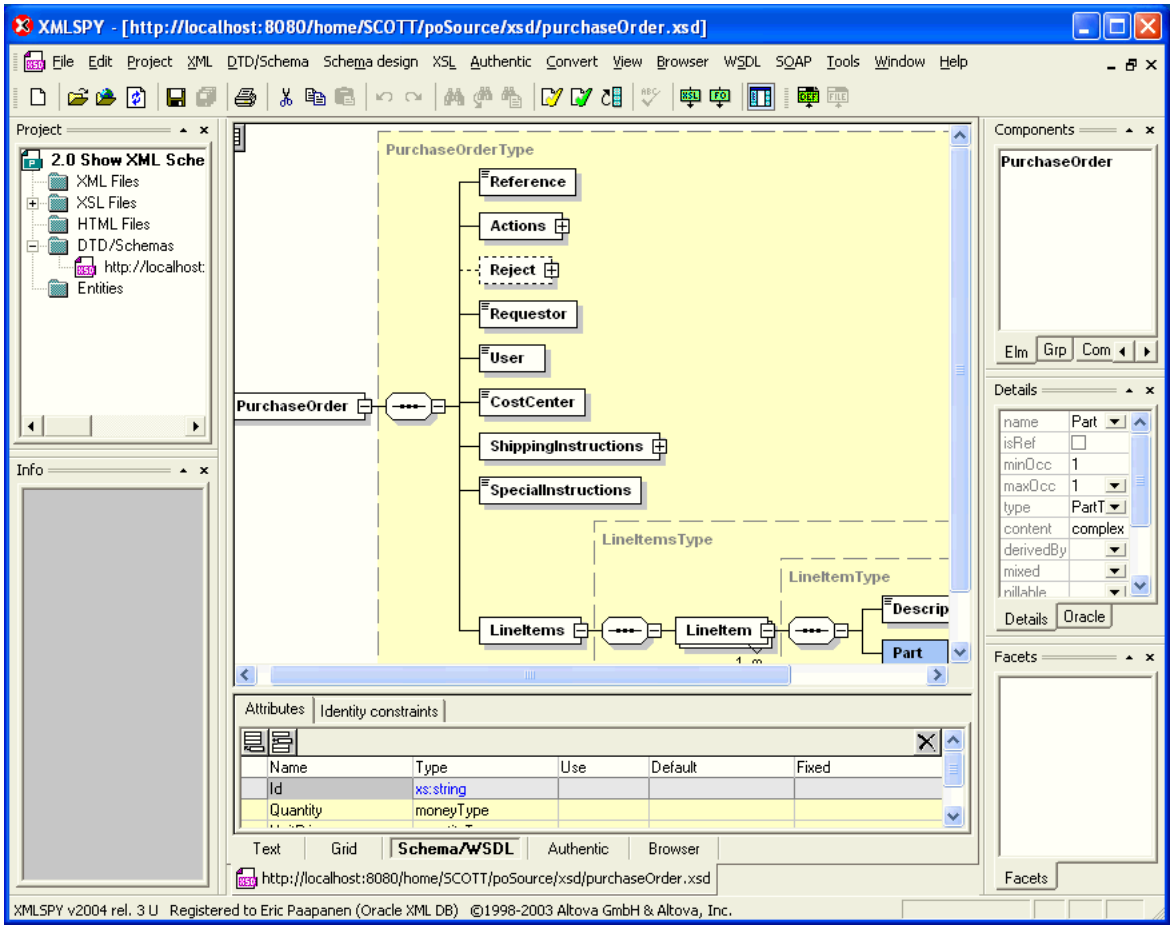
Overview of Editing XML Schemas

XML schemas can be authored and edited using any of the following:

- A simple text editor, such as emacs or vi
- An XML schema-aware editor, such as the XML editor included with Oracle JDeveloper
- An explicit XML schema-authoring tool, such as XMLSpy from Altova Corporation

Figure 17–1 shows a purchase-order XML schema being edited using XMLSpy. XMLSpy is a graphical XML tool from Altova Corporation that you can use to create and edit XML schemas and other XML documents. See `http://www.altova.com` for details.[1]

Figure 17–1 XMLSpy Graphical Representation of a Purchase-Order XML Schema



Overview of Using XML Schema with Oracle XML DB

Oracle XML DB takes advantage of the strong typing and other features of XML Schema to process XML database data safely and efficiently.

XML schemas are stored in Oracle XML DB as `XMLType` instances, just like the XML documents that reference them. You must *register* an XML schema with Oracle XML DB in order to use it with XML data that is stored in the database.

To be registered with Oracle XML DB, an XML schema must conform to the the **root XML Schema**, **XDBSchema.xsd**. This is the XML schema for Oracle XML DB XML schemas. You can access `XDBSchema.xsd` at Oracle XML DB Repository location `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBSchema.xsd`.

Oracle XML DB uses *annotated* XML schemas as metadata. The standard XML Schema definitions are used, along with several Oracle namespace attributes. These attributes

[1] XMLSpy also supports WebDAV and FTP protocols, so you can use it to directly access and edit content stored in Oracle XML DB Repository.

determine how XML instance documents get mapped to the database. Because these attributes are in a different namespace from the XML Schema namespace, such annotated XML schemas respect the XML Schema standard.

Oracle XML DB provides XML Schema support for the following tasks:

- Registering W3C-compliant XML schemas, both local and global.
- Validating your XML documents against registered XML schema definitions.
- Generating XML schemas from SQL object types.
- Referencing an XML schema owned by another user.
- Referencing a global XML schema when a local XML schema exists with the same name.
- Generating a database mapping from your XML schemas during XML schema registration. This includes generating SQL object types, collection types, and default tables, and capturing the mapping information using XML schema attributes.
- Specifying a particular SQL data type mapping when there are multiple allowed mappings.
- Creating `XMLType` tables, views, and columns based on registered XML schemas.
- Manipulating and querying XML schema-based `XMLType` tables.
- Automatically inserting data into default tables when XML schema-based documents are inserted into Oracle XML DB Repository using protocols (FTP, HTTP(S)/WebDAV) and languages other than SQL.

Why Use XML Schema with Oracle XML DB?

These are some of the reasons to use XML Schema with Oracle XML DB:

- The most common use of XML Schema is as a mechanism for *validating* that XML instance documents conform to a given XML schema, that is, verify that your XML data conforms to its intended definition. This definition includes data types, numbers of allowed item occurrences, and allowed lengths of items.
- An XML schema can also be used as a *constraint* when creating `XMLType` tables or columns. For example, the table or column can be constrained to store only XML documents that compliant with one of the global elements defined by the XML schema.
- Oracle XML DB also uses XML Schema as a mechanism for defining how the contents of an `XMLType` instance should be stored inside the database. Both binary XML and object-relational storage models for `XMLType` support the use of XML Schema. When `XMLType` data is stored object-relationally, XML Schema is used to efficiently map XML Schema data types to SQL data types and object-relational tables and columns.
- XML schema information can also improve the efficiency of document insertion when you storing XML Schema-based documents in Oracle XML DB using protocols FTP and HTTP(S).
- When XML instances must be handled without any prior information about them, XML schemas can be useful in predicting optimum storage, fidelity, and access.

See Also: "XMLType Storage Models" on page 1-11

Overview of Annotating an XML Schema to Control Naming, Mapping, and Storage

The W3C XML Schema Recommendation defines an annotation mechanism that lets vendor-specific information be added to an XML schema. Oracle XML DB uses this mechanism to control the mapping between the XML schema and various database features.

You can use XML schema annotations with Oracle XML DB to do the following:

- Specify which database tables are used to store the XML data.
- Override the default mapping between XML Schema data types and SQL data types, for object-relational storage.
- Name the database objects and attributes that are created to store XML data (for object-relational storage).

Example A–2 on page A-34 shows an annotated purchase-order XML schema. It defines the following two XML namespaces:

- `http://www.w3c.org/2001/XMLSchema`. This is reserved by W3C for the Schema for Schemas.
- `http://xmlns.oracle.com/xdb`. This is reserved by Oracle for the Oracle XML DB schema annotations.

Before annotating an XML schema you *must* declare the Oracle XML DB namespace. The Oracle XML DB namespace is `http://xmlns.oracle.com/xdb`. Example A–2 makes use of the namespace *prefix* **`xdb`** to abbreviate the Oracle XML DB namespace.

Example A–2 uses several XML schema annotations, including the following:

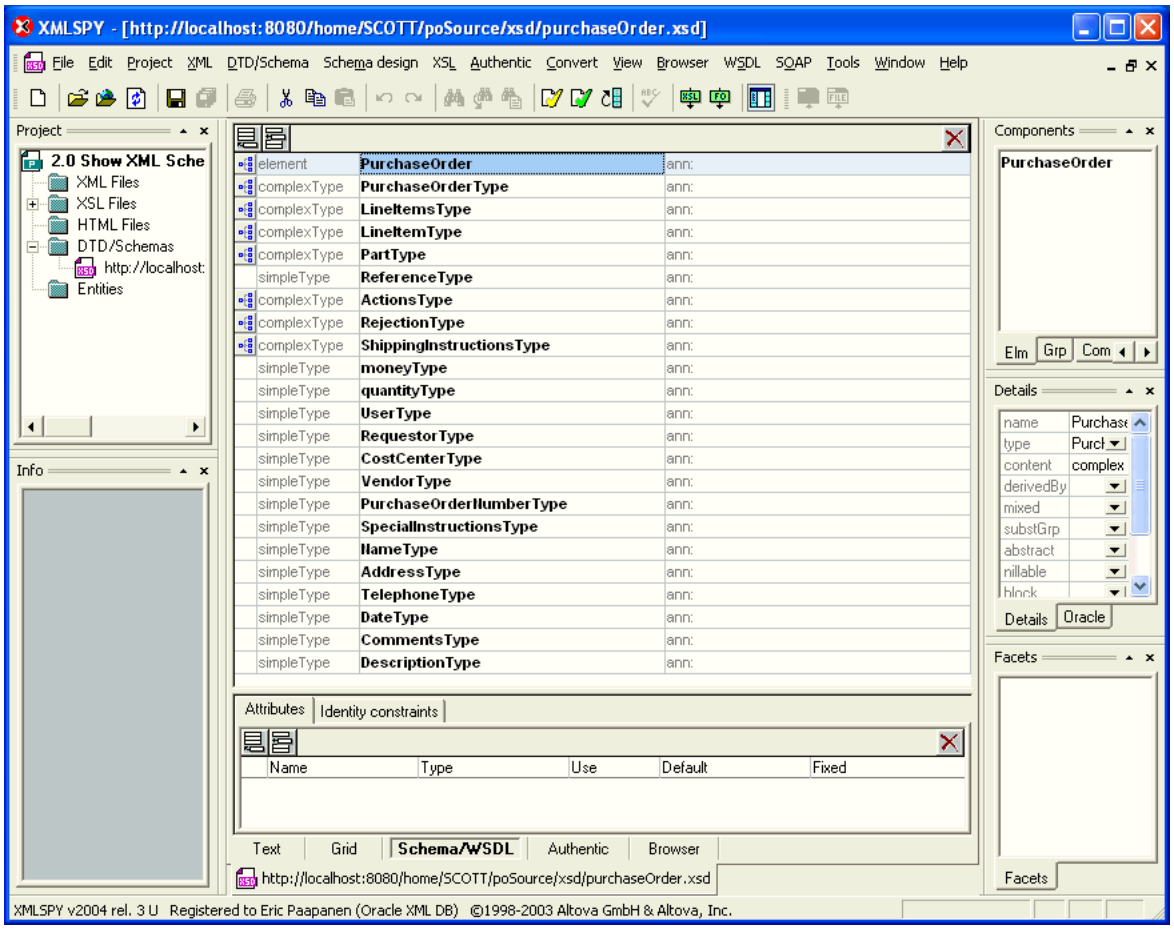
- `defaultTable` annotation in the `PurchaseOrder` element. This specifies that XML documents, compliant with this XML schema are stored in a database table called `purchaseorder`.
- `SQLType` annotation.

  The first occurrence of annotation `SQLType` specifies that the name of the SQL data type generated from `complexType` element `PurchaseOrderType` is `purchaseorder_t`.

  The second occurrence of annotation `SQLType` specifies that the name of the SQL data type generated from `complexType` element `LineItemType` is `lineitem_t`.
- `SQLCollType` annotation. This specifies that the name of the SQL varray type that manages the collection of `LineItem` elements is `lineitem_v`.
- `SQLName` annotation. This provides an explicit name for each SQL object attribute of `purchaseorder_t`.

Figure 17–2 shows the XMLSpy **Oracle** tab, which facilitates adding Oracle XML DB annotations to an XML schema while working in the graphical editor.

Figure 17–2 XMLSpy Support for Oracle XML DB Schema Annotations



DOM Fidelity

Document Object Model (DOM) fidelity is the concept of retaining the structure of a retrieved XML document, compared to the original XML document, for DOM traversals. You can use DOM fidelity to ensure the accuracy and integrity of XML documents stored in Oracle XML DB.

DOM fidelity means that all information in an XML document is preserved, except whitespace that is insignificant. With DOM fidelity, XML data retrieved from the database has the same information as before it was inserted into the database, with the single exception of insignificant whitespace. The term "DOM fidelity" is used because this kind of fidelity is particularly important for DOM traversals.

With binary XML storage of XML data, all of the significant information is encoded in the binary XML format, ensuring DOM fidelity.

> **See Also:** "SYS_XDBPD$ and DOM Fidelity for Object-Relational Storage" on page 18-5 for information about DOM fidelity and object-relational storage of XML data

XMLType Methods Related to XML Schema

Table 17–1 lists some of the `XMLType` methods that are useful for working with XML schemas.

Table 17–1 XMLType Methods Related to XML Schema

XMLType Method	Description
`isSchemaBased()`	Returns `TRUE` if the `XMLType` instance is based on an XML schema, `FALSE` otherwise.
`getSchemaURL()`	The XML schema URL for an `XMLType` instance.

`schemaValidate()`
`isSchemaValid()`
`isSchemaValidated()`
`setSchemaValidated()`
	Validation of an `XMLType` instance against a registered XML schema: validate, check validation status, or set recorded validation status. See Chapter 7, "Transformation and Validation of XMLType Data".

XML Schema Registration with Oracle XML DB

Before an XML schema can be used by Oracle XML DB, you must register it with Oracle Database. After it has been registered it can be used for validating XML documents and for creating `XMLType` tables and columns.

Like all DDL operations, XML schema registration is non-transactional. However, registration is *atomic*, in this sense:

- If registration succeeds then the operation is auto-committed.
- If registration fails then the database is rolled back to the state it had before registration began.

Because XML schema registration potentially involves creating object types and tables, error recovery involves dropping any types and tables thus created. The entire XML schema registration process is guaranteed to be atomic: either it succeeds or the database is restored to its state before the start of registration.

Two items are required to register an XML schema with Oracle XML DB:

- The XML schema document
- A string that can be used as a unique identifier for the XML schema, after it is registered with Oracle Database. XML instance documents use this unique identifier to identify themselves as members of the class defined by the XML schema. The identifier is typically in the form of a URL, and is often referred to as the **schema location hint** or the **document location hint**.

> **Note:** The act of registering an XML schema has *no effect* on the status of any instance documents that are *already loaded* into Oracle XML DB Repository and that reference that XML schema.
>
> Such instance documents were treated as non XML-schema-based when they were loaded. They remain such. After schema registration, you must *delete* such documents and *reload* them, in order to obtain XML schema-based documents.

XML Schema Registration Actions

As part of registering an XML schema, Oracle XML DB also performs several actions that facilitate storing, accessing, and manipulating XML instances that conform to the XML schema. These include:

- Mapping XML Schema data types to Oracle XML DB storage. When XML schema-based data is stored, its storage data types are derived from the XML Schema data types using a default mapping and, optionally, using mapping information that you specify using XML schema annotations. For binary XML

storage, XML Schema types are mapped to binary XML encoding types. For object-relational storage, XML schema registration creates the appropriate SQL object types for the object-relational storage of conforming documents.

- Creating default tables. XML schema registration generates default `XMLType` tables for all global elements. You can use XML-schema annotations to control the names of the tables, and to provide column-level and table-level storage clauses and constraints for use during table creation.

  See Also:

  - "XML Schema Data Types Are Mapped to Oracle XML DB Storage" on page 17-24
  - "Default Tables Created during XML Schema Registration" on page 18-4
  - "Oracle XML Schema Annotations" on page 18-6

After XML schema registration, documents that reference the XML schema using the XML Schema instance mechanism can be processed automatically by Oracle XML DB. For XML data that is stored object-relationally, `XMLType` tables and columns can be created that are constrained to the global elements defined by the XML schema.

Registering an XML Schema with Oracle XML DB

You use PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema` to register an XML schema. The main parameters to this procedure are as follows:

- `SCHEMAURL` – the XML schema URL. This is a unique identifier for the XML schema within Oracle XML DB. It is conventionally in the form of a URL, but this is not a requirement. The XML schema URL is used with Oracle XML DB to identify instance documents, by making the schema location hint identical to the XML schema URL. Oracle XML DB never tries to access a Web server identified by the specified URL.

  Note: You cannot register an XML schema using the same `SCHEMAURL` as any system-defined XML schema.

- `SCHEMADOC` – The XML schema source document. This is a `VARCHAR`, `CLOB`, `BLOB`, `BFILE`, `XMLType`, or `URIType` value.
- `CSID` – The character-set ID of the source-document encoding, when `schemaDoc` is a `BFILE` or `BLOB` value.
- `OPTIONS` – Options that specify how the XML schema should be registered. The most important option is `REGISTER_BINARYXML`, which indicates that the XML schema is used for binary XML storage. Another option is `REGISTER_NT_AS_IOT`, which forces OCTs to be stored as index-organized tables (IOTs).

  See Also: *Oracle Database PL/SQL Packages and Types Reference*

Example 17–1 registers the annotated XML schema of Example A–2 on page A-34.

Example 17–1 Registering an XML Schema Using DBMS_XMLSCHEMA.REGISTERSCHEMA

```
BEGIN
```

```
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd',
    SCHEMADOC => XDBURIType('/source/schemas/poSource/xsd/purchaseOrder.xsd').getCLOB(),
    LOCAL     => TRUE,
    GENTYPES  => TRUE,
    GENTABLES => TRUE);
END;
/
```

In Example A–2, the unique identifier for the XML schema is:

```
http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd
```

The XML schema document was previously loaded into Oracle XML DB Repository at this path: `/source/schemas/poSource/xsd/purchaseOrder.xsd`.

During XML schema registration, option `SCHEMADOC` specifies that PL/SQL constructor `XDBURIType` is to access the content of the XML schema document, based on its location in the repository. Other options passed to procedure `registerSchema` specify that the schema in Example A–2 is to be registered as a local XML schema (option `LOCAL`), and that SQL objects, and that tables are to be generated during the registration process (option `GENTABLES`).

PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema` performs the following operations:

- Parses and validates the XML schema.
- Creates a set of entries in Oracle Data Dictionary that describe the XML schema.
- Creates a set of SQL object definitions, based on `complexType` elements defined in the XML schema.
- Creates an `XMLType` table for each global element defined by the XML schema.

By default, when an XML schema is registered, Oracle XML DB automatically generates all of the SQL object types and `XMLType` tables required to manage the instance documents. An XML schema can be registered as global or local.

See Also:

- "Local and Global XML Schemas" on page 17-11
- "SQL Types and Tables Created During XML Schema Registration" on page 17-9
- *Oracle Database PL/SQL Packages and Types Reference* for information about `DBMS_XMLSCHEMA.registerSchema`

SQL Types and Tables Created During XML Schema Registration

Example 17–2 shows the object types created during an XML schema registration such as that of Example 17–1.

Example 17–2 Objects Created During XML Schema Registration

```
DESCRIBE purchaseorder_t
 purchaseorder_t is NOT FINAL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 SYS_XDBPD$                                         XDB.XDB$RAW_LIST_T
 REFERENCE                                          VARCHAR2(30 CHAR)
 ACTIONS                                            ACTIONS_T
 REJECTION                                          REJECTION_T
```

```
 REQUESTOR                                          VARCHAR2(128 CHAR)
 USERID                                             VARCHAR2(10 CHAR)
 COST_CENTER                                        VARCHAR2(4 CHAR)
 SHIPPING_INSTRUCTIONS                              SHIPPING_INSTRUCTIONS_T
 SPECIAL_INSTRUCTIONS                               VARCHAR2(2048 CHAR)
 LINEITEMS                                          LINEITEMS_T

DESCRIBE lineitems_t
 lineitems_t is NOT FINAL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 SYS_XDBPD$                                         XDB.XDB$RAW_LIST_T
 LINEITEM                                           LINEITEM_V

DESCRIBE lineitem_v
 lineitem_v VARRAY(2147483647) OF LINEITEM_T
 LINEITEM_T is NOT FINAL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 SYS_XDBPD$                                         XDB.XDB$RAW_LIST_T
 ITEMNUMBER                                         NUMBER(38)
 DESCRIPTION                                        VARCHAR2(256 CHAR)
 PART                                               PART_T
```

This example shows that SQL type definitions were created when the XML schema was registered with Oracle XML DB. These SQL type definitions include:

- `purchaseorder_t`. This type is used to persist the SQL objects generated from a `PurchaseOrder` element. When an XML document containing a `PurchaseOrder` element is stored in Oracle XML DB the document is broken up, and the contents of the document are stored as an instance of `purchaseorder_t`.
- `lineitems_t`, `lineitem_v`, and `lineitem_t`. These types manage the collection of `LineItem` elements that may be present in a `PurchaseOrder` document. Type `lineitems_t` consists of a single attribute `lineitem`, defined as an instance of type `lineitem_v`. Type `lineitem_v` is defined as a varray of `linteitem_t` objects. There is one instance of the `lineitem_t` object for each `LineItem` element in the document.

Guidelines for Working with Global Elements

By default, when an XML schema is registered with the database, Oracle XML DB generates a *default table for each global element* defined by the XML schema.

You can use attribute `xdb:defaultTable` to specify the name of the default table for a given global element. Each `xdb:defaultTable` attribute value you provide must be *unique* among *all schemas* registered by a given database user. If you do *not* supply a nonempty default table name for some element, then a unique name is provided automatically.

In practice, however, you do *not* want to create a default table for most global elements. Elements that never serve as the root element for an XML instance document do not need default tables—such tables are never used. Creating default tables for all global elements can lead to significant overhead in processor time and space used, especially if an XML schema contains a large number of global element definitions.

As a general rule, then, you want to prevent the creation of a default table for any global element (or any local element stored out of line) that you are sure will *not* be used as a root element in any document. You can do this in one of the following ways:

- Add the annotation `xdb:defaultTable = ""` (empty string) to the definition of *each* global element that will *not* appear as the root element of an XML instance

document. Using this approach, you allow automatic default-table creation, in general, and you prohibit it explicitly where needed, using `xdb:defaultTable = ""`.

- Set parameter `GENTABLES` to `FALSE` when registering the XML schema, and then *manually create the default table* for each global element that can legally appear as the root element of an instance document. Using this approach, you inhibit automatic default-table creation, and you create only the tables that are needed, by hand.

Database Objects That Depend on Registered XML Schemas

The following database objects are dependent on registered XML schemas:

- Tables or views that have an `XMLType` column that conforms to an element in an XML schema.
- Other XML schemas that include or import a given XML schema as part of their definition.
- Cursors that reference an XML schema. This includes references within functions of package `DBMS_XMLGEN`. Such cursors are purely transient objects.

Local and Global XML Schemas

XML schemas can be registered as local or global:

- A local xml schema is, by default, visible only to its owner.
- A global xml schema is, by default, visible and usable by all database users.

When you register an XML schema, PL/SQL package `DBMS_XMLSCHEMA` adds a corresponding resource to Oracle XML DB Repository. The XML schema URL determines the path name of the XML schema resource in the repository (and it is associated with parameter `SCHEMAURL` of PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema`).

Note: In Oracle Enterprise Manager, local and global registered XML schemas are referred to as **private** and **public**, respectively.

Local XML Schema

By default, an XML schema belongs to you after you register it with Oracle XML DB. A reference to the XML schema document is stored in Oracle XML DB Repository. Such XML schemas are referred to as **local**. By default, they are usable only by you, the owner. In Oracle XML DB, local XML schema resources are created under folder `/sys/schemas/`*`username`*. The rest of the repository path name is derived from the schema URL.

Example 17–3 Registering a Local XML Schema

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    SCHEMADOC => bfilename('XMLDIR','purchaseOrder.xsd'),
    LOCAL     => TRUE,
    GENTYPES  => TRUE,
    GENTABLES => FALSE,
    CSID      => nls_charset_id('AL32UTF8'));
```

```
END;
/
```

If this local XML schema is registered by user QUINE, it is given this path name:

```
/sys/schemas/QUINE/xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd
```

Database users need appropriate permissions and Access Control Lists (ACLs) to create a resource with this path name, in order to register the XML schema as a local XML schema.

> **See Also:** Chapter 27, "Repository Access Control"

> **Note:** Typically, only the owner of the XML schema can use it to define XMLType tables, columns, or views, validate documents, and so on. However, Oracle XML DB supports fully qualified XML schema URLs. For example: http://xmlns.oracle.com/xdb/schemas/QUINE/xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd. Privileged users can use such an extended URL to specify XML schemas belonging to other users.

Global XML Schema

In contrast to local schemas, a privileged user can register an XML schema as global by specifying an argument in the DBMS_XMLSCHEMA registration function. **Global XML schemas** are visible to *all* users. They are stored under folder /sys/schemas/PUBLIC/ in Oracle XML DB Repository.

> **Note:** Access to folder /sys/schemas/PUBLIC is controlled by access control lists (ACLs). By default, this folder is writable only by a database administrator. You need write privileges on this folder to register global XML schemas. Role XDBADMIN provides write access to this folder, assuming that it is protected by the default ACLs. See Chapter 27, "Repository Access Control".

You can register a local schema with the same URL as an existing global schema. A local schema always shadows (hides) any global schema with the same name (URL). Example 17–4 illustrates registration of a global schema.

Example 17–4 Registering a Global XML Schema

```
GRANT XDBADMIN TO QUINE;

Grant succeeded.

CONNECT quine
Enter password: password

Connected.

BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    SCHEMADOC => bfilename('XMLDIR','purchaseOrder.xsd'),
    LOCAL     => FALSE,
```

```
    GENTYPES  => TRUE,
    GENTABLES => FALSE,
    CSID      => nls_charset_id('AL32UTF8'));
END;
/
```

If this global XML schema is registered by user `QUINE`, it is given this path name:

```
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd
```

Database users need appropriate permissions (ACL access) to create this resource in order to register the XML schema as global.

Fully Qualified XML Schema URLs

By default, XML schema URLs are referenced within the scope of the current database user. XML schema URLs are first resolved as the names of *local* XML schemas owned by the current user.

- If there are no such XML schemas, then they are resolved as names of *global* XML schemas.
- If there are no *global* XML schemas either, then Oracle XML DB raises an error.

To permit explicit reference to particular XML schemas, Oracle XML DB supports the notion of *fully qualified* XML schema URLs. The name of the database user owning the XML schema is specified as part of the XML schema URL. Fully qualified XML schema URLs belong to the Oracle XML DB namespace:

```
http://xmlns.oracle.com/xdb/schemas/<database-user>/<schemaURL-minus-protocol>
```

For example, suppose there is a registered global XML schema with the URL `http://www.example.com/po.xsd`, and user `QUINE` has a local registered XML schema with the same URL. Another user can reference the schema owned by `QUINE` as follows using this fully qualified XML Schema URL:

```
http://xmlns.oracle.com/xdb/schemas/QUINE/www.example.com/po.xsd
```

The fully qualified URL for the global XML schema is:

```
http://xmlns.oracle.com/xdb/schemas/PUBLIC/www.example.com/po.xsd
```

See Also: "Local and Global XML Schemas" on page 17-11

Deleting an XML Schema

You can delete a registered XML schema by using procedure `DBMS_XMLSCHEMA.deleteSchema`. This does the following, by default:

1. Checks that the current user has the appropriate privileges to delete the resource corresponding to the XML schema within Oracle XML DB Repository. You can control which users can delete which XML schemas, by setting the appropriate ACLs on the XML schema resources.
2. Checks whether there are any tables dependent on the XML schema that is to be deleted. If so, raises an error and cancels the deletion. This check is not performed if option `delete_invalidate` or `delete_cascade_force` is used. In that case, no error is raised.
3. Removes the XML schema document from the Oracle XML DB Repository (folder `/sys/schemas`).

4. Removes the XML schema document from DBA_XML_SCHEMAS, unless it was registered for use with binary XML instances and neither delete_invalidate nor delete_cascade_force is used.
5. Drops the default table, if either delete_cascade or delete_cascade_force is used. Raises an error if delete_cascade is specified and there are instances in other tables that are also dependent on the XML schema.

The following values are available for option DELETE_OPTION of procedure DBMS_XMLSCHEMA.deleteSchema:

- DELETE_RESTRICT – Raise an error and cancel deletion if dependencies are detected. This is the default behavior.
- DELETE_INVALIDATE – Do not raise an error if dependencies are detected. Instead, mark each of the dependencies as being invalid.
- DELETE_CASCADE – Drop all types and default tables that were generated during XML schema registration. Raise an error if there are instances that depend upon the XML schema that are stored in tables other than the default table. However, do not raise an error for any such instances that are stored in XMLType columns that were created using ANY_SCHEMA. If the XML schema was registered for use with binary XML, do not remove it from DBA_XML_SCHEMAS.
- DELETE_CASCADE_FORCE – Drop all types and default tables that were generated during XML schema registration. Do not raise an error if there are instances that depend upon the XML schema that are stored in tables other than the default table. Instead, mark each of the dependencies as being invalid. Remove the XML schema from DBA_XML_SCHEMAS.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Example 17–5 illustrates the use of DELETE_CASCADE_FORCE.

Example 17–5 Deleting an XML Schema with DBMS_XMLSCHEMA.DELETESCHEMA

```
BEGIN
  DBMS_XMLSCHEMA.deleteSchema(
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    DELETE_OPTION => DBMS_XMLSCHEMA.DELETE_CASCADE_FORCE);
END;
/
```

If an XML schema was registered for use with binary XML, it is not removed from DBA_XML_SCHEMAS when you delete it using option DELETE_RESTRICT (the default value) or DELETE_CASCADE. As a consequence, although you can no longer use the XML schema to encode new XML instance documents, any existing documents in Oracle XML DB that reference the XML schema can still be *decoded* using it.

This remains the case until you remove the XML schema from DBA_XML_SCHEMAS using DBMS_XMLSCHEMA.**purgeSchema**. Oracle recommends that, in general, you use delete_restrict or delete_cascade. Instead of using DELETE_CASCADE_FORCE, call DBMS_XMLSCHEMA.purgeSchema when you are sure you no longer need the XML schema.

Procedure purgeSchema removes the XML schema completely from Oracle XML DB. In particular, it removes it from DBA_XML_SCHEMAS. Before you use DBMS_XMLSCHEMA.purgeSchema, be sure that you have transformed all existing XML documents that reference the XML schema to be purged, so they reference a different XML schema or no XML schema. Otherwise, it will be impossible to decode them after the purge.

Listing All Registered XML Schemas

Example 17–6 shows how to use PL/SQL procedure DBMS_XMLSCHEMA.registerSchema to obtain a list of all XML schemas registered with Oracle XML DB. You can also examine views USER_XML_SCHEMAS, ALL_XML_SCHEMAS, USER_XML_TABLES, and ALL_XML_TABLES.

Example 17–6 Data Dictionary Table for Registered Schemas

```
DESCRIBE DBA_XML_SCHEMAS

Name          Null? Type
------------ ----- ----------------------
OWNER               VARCHAR2(30)
SCHEMA_URL          VARCHAR2(700)
LOCAL               VARCHAR2(3)
SCHEMA              XMLTYPE(XMLSchema "http://xmlns.oracle.com/xdb/XDBSchema.xsd"
                            Element "schema")
INT_OBJNAME         VARCHAR2(4000)
QUAL_SCHEMA_URL     VARCHAR2(767)
HIER_TYPE           VARCHAR2(11)
BINARY              VARCHAR2(3)
SCHEMA_ID           RAW(16)
HIDDEN              VARCHAR2(3)

SELECT OWNER, LOCAL, SCHEMA_URL FROM DBA_XML_SCHEMAS;

OWNER   LOC   SCHEMA_URL
-----   ---   ----------------------
XDB     NO    http://xmlns.oracle.com/xdb/XDBSchema.xsd
XDB     NO    http://xmlns.oracle.com/xdb/XDBResource.xsd
XDB     NO    http://xmlns.oracle.com/xdb/acl.xsd
XDB     NO    http://xmlns.oracle.com/xdb/dav.xsd
XDB     NO    http://xmlns.oracle.com/xdb/XDBStandard.xsd
XDB     NO    http://www.w3.org/2001/xml.xsd
XDB     NO    http://xmlns.oracle.com/xdb/stats.xsd
XDB     NO    http://xmlns.oracle.com/xdb/xdbconfig.xsd
SCOTT   YES   http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd

13 rows selected.

DESCRIBE DBA_XML_TABLES

Name          Null? Type
------------ ----- ----------------------
OWNER               VARCHAR2(30)
TABLE_NAME          VARCHAR2(30)
XMLSCHEMA           VARCHAR2(700)
SCHEMA_OWNER        VARCHAR2(30)
ELEMENT_NAME        VARCHAR2(2000)
STORAGE_TYPE        VARCHAR2(17)
ANYSCHEMA           VARCHAR2(3)
NONSCHEMA           VARCHAR2(3)

SELECT TABLE_NAME FROM DBA_XML_TABLES
  WHERE XMLSCHEMA = 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd';

TABLE_NAME
---------------------
PurchaseOrder1669_TAB
```

```
1 row selected.
```

Creating XMLType Tables and Columns Based on XML Schemas

Using Oracle XML DB, you can create XMLType tables and columns that are constrained to a global element defined by a registered XML schema. After an XMLType column has been constrained to a particular element and a particular XML schema, it can only contain documents that are compliant with the schema definition of that element. You constrain an XMLType table column to a particular element and XML schema by adding appropriate XMLSCHEMA and ELEMENT clauses to the CREATE TABLE operation.

Figure 17–3 through Figure 17–6 show the syntax for creating an XMLType table.

> **See Also:** *Oracle Database SQL Language Reference* for the complete description of CREATE TABLE, including syntax elements such as object_properties.

> **Note:** To create an XMLType table in a different database schema from your own, you must have not only privilege CREATE ANY TABLE but also privilege CREATE ANY INDEX. This is because a unique index is created on column OBJECT_ID when you create the table. Column OBJECT_ID stores a system-generated object identifier.

Figure 17–3 Creating an XMLType Table – CREATE TABLE Syntax

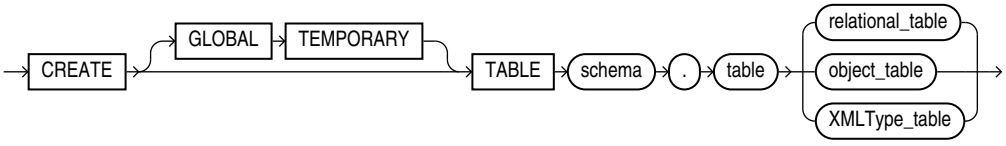


Figure 17–4 Creating an XMLType Table – XMLType_table Syntax

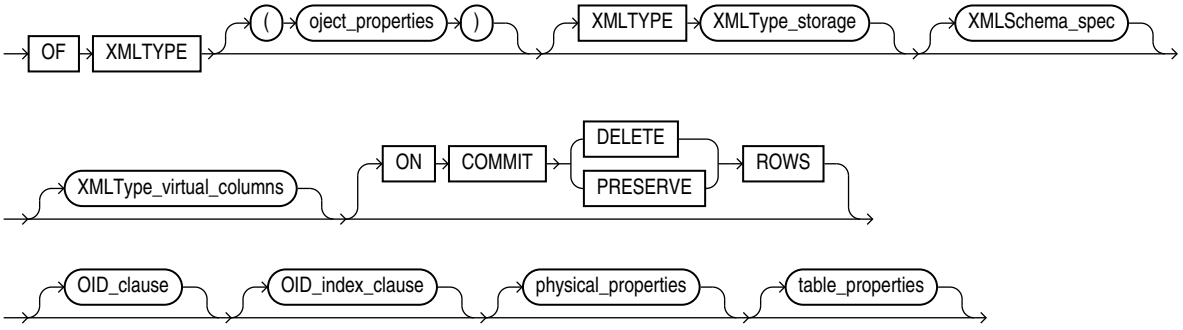


Figure 17–5 Creating an XMLType Table – table_properties Syntax

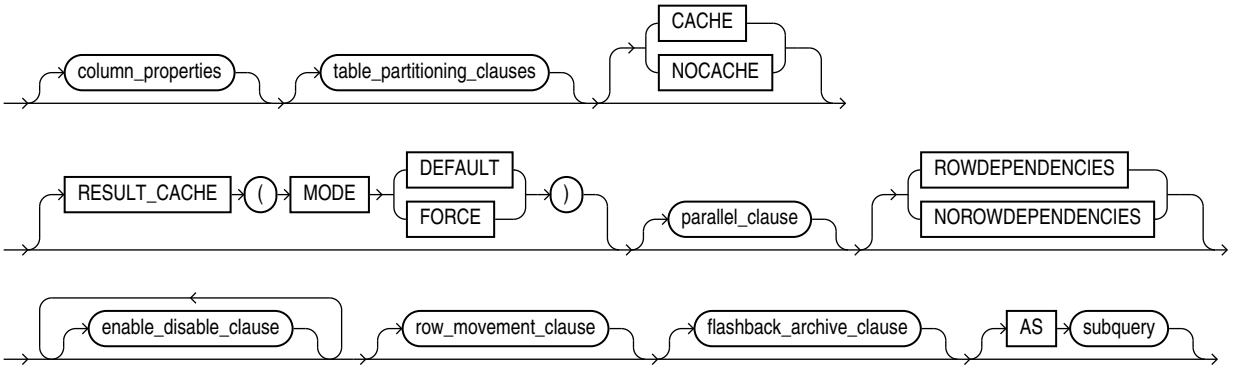
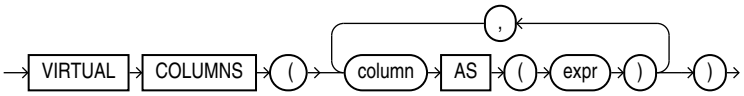


Figure 17–6 Creating an XMLType Table – XMLType_virtual_columns Syntax



Note:

- Clause `XMLType_virtual_columns` can be used only for `XMLType` data that is stored as *binary XML*. In particular, if you use it for data that is stored object-relationally, and if you use a partitioning clause, then an error is raised.
- For XML data, virtual columns are used primarily for partitioning or defining SQL constraints. If your need is to project out specific XML data in order to access it relationally, then consider using SQL/XML function `XMLTable` or `XMLIndex` with a structured component.

See also:

- "Creating Virtual Columns on XMLType Data Stored as Binary XML" on page 3-2
- "XMLTABLE SQL/XML Function in Oracle XML DB" on page 4-11
- "XMLIndex Structured Component" on page 6-8

A subset of the XPointer notation can also be used to provide a single URL that contains the XML schema location and element name. See also Chapter 5, "Query and Update of XML Data".

Example 17–7 shows two `CREATE TABLE` statements. The first creates `XMLType` table `purchaseorder_as_table`. The second creates relational table `purchaseorder_as_column`, which has `XMLType` column `xml_document`. In each table, the `XMLType` instance is constrained to the `PurchaseOrder` element that is defined by the XML schema registered with URL `http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd`.

Example 17–7 Creating XML Schema-Based XMLType Tables and Columns

```
CREATE TABLE purchaseorder_as_table OF XMLType
  XMLSCHEMA "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
```

```
  ELEMENT "PurchaseOrder";

CREATE TABLE purchaseorder_as_column (id NUMBER, xml_document XMLType)
  XMLTYPE COLUMN xml_document
  ELEMENT
    "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd#PurchaseOrder";
```

There are two ways to specify `XMLSchema` and `Element`:

- as separate clauses, `XMLSchema` and `Element`
- using only the `Element` clause with an XPointer notation

The data associated with an `XMLType` table or column that is constrained to an XML schema can be stored in different ways:

- Decomposed and stored object-relationally
- Stored as binary XML, using a single binary-XML column

Specification of XMLType Storage Options for XML Schema-Based Data

You can specify storage options to use when you manually create a table that stores XML instance documents that reference an XML schema. To specify a particular `XMLType` storage model, use a `STORE AS` clause in the `CREATE TABLE` statement. Otherwise, the storage model specified during registration of the XML schema is used. If no storage model was specified during registration, then object-relational storage is used.

This section describes what you need to know about specifying storage options for XML schema-based data. You can also specify storage options for tables that are created automatically, by using XML schema annotations.

See Also:

- "Oracle XML Schema Annotations" on page 18-6
- Chapter 16, "Choice of XMLType Storage and Indexing"

Binary XML Storage of XML Schema-Based Data

If you specify `STORE AS BINARY_XML`, then binary XML storage is used. If you specify an XML schema that the XML documents must conform to, then you can use that XML schema only to create `XMLType` tables and columns that are stored as binary XML. You *cannot* use the same XML schema to create `XMLType` tables and columns that are stored object-relationally.

The converse is also true: If you use object-relational storage for the registered XML schema, then you can use only that XML schema to create `XMLType` tables and columns that are stored as binary XML.

Binary XML storage offers a great deal of flexibility for XML data, especially concerning the use of XML schemas. Binary XML encodes XML data differently, depending upon whether or not an XML schema is used for the encoding, and it can encode the same data differently using different XML schemas.

When an XML schema is taken into account for encoding binary XML data, the XML Schema data types are mapped to encoded types for storage. Alternatively, you can encode XML data as non-schema-based binary XML, whether or not the data references an XML schema. In that case, any referenced XML schema is ignored, and there is no encoding of XML Schema data types.

When you create an XMLType table or column and you use binary XML storage, you can specify how to encode the column or table to make use of XML schemas. Choose from among these possibilities:

- Encode the column or table data as *non-schema-based* binary XML. The XML data stored in the column can nevertheless conform to an XML schema, but it need not. Any referenced XML schema is ignored for encoding purposes, and documents are not automatically validated when they are inserted or updated.

  You can nevertheless explicitly validate an XML schema-based document that is encoded as non-schema-based binary XML. This represents an important use case: situations where you do not want to tie documents too closely to a particular XML schema, because you might change it or delete it.

- Encode the column or table data to conform to a *single XML schema*. All rows (documents) must conform to the same XML schema. You can nevertheless specify, as an option, that non-schema-based documents can also be stored in the same column.

- Encode the column or table data to conform to whatever XML schema it references Each row (document) can reference *any XML schema*, and that XML schema is used to encode that particular XML document. In this case also, you can specify, as an option, that non-schema-based documents can also be stored in the same column.

  You can use multiple *versions* of the same XML schema in this way. Store documents that conform to different versions. Each is encoded according to the XML schema that it references.

You can specify that any XML schema can be used for encoding by using option ALLOW ANYSCHEMA when you create the table.

Note:

- If you use option ALLOW ANYSCHEMA, then any XML schema referenced by your instance documents is used *only for validation*. It is *not* used at query time. Queries of your data treat it as if it were non XML schema-based data.

- Oracle recommends that you do *not* use option ALLOW ANYSCHEMA if you anticipate using copy-based XML schema evolution (see "Copy-Based Schema Evolution" on page 20-2). If you use this option, it is impossible to determine which rows (documents) might conform to the XML schema that is evolved. Conforming rows are not transformed during copy-based evolution, and afterward they are not decodable.

You can specify, for tables and columns that use XML schema-based encodings, that they can accept also non-schema-based documents by using option ALLOW NONSCHEMA. In the absence of keyword XMLSCHEMA, encoding is for non-schema-based documents. In the absence of the keywords ALLOW NONSCHEMA but the presence of keyword XMLSCHEMA, encoding is for the single XML schema specified. In the absence of the keywords ALLOW NONSCHEMA but the presence of the keywords ALLOW ANYSCHEMA, encoding is for any XML schema that is referenced.

An error is raised if you try to insert an XML document into an XMLType table or column that does not correspond to the document.

The various possibilities are summarized in Table 17–2.

Table 17–2 CREATE TABLE Encoding Options for Binary XML

Storage Options	Encoding Effect
`STORE AS BINARY XML`	Encodes all documents using the non-schema-based encoding.
`STORE AS BINARY XML XMLSCHEMA ...`	Encodes all documents using an encoding based on the referenced XML schema. Trying to insert or update a document that does not conform to the XML schema raises an error.
`STORE AS BINARY XML XMLSCHEMA ... ALLOW NONSCHEMA`	Encodes all XML schema-based documents using an encoding based on the referenced XML schema. Encodes all non-schema-based documents using the non-schema-based encoding. Trying to insert or update an XML schema-based document that does not conform to the referenced XML schema raises an error.
`STORE AS BINARY XML ALLOW ANYSCHEMA`	Encodes all XML schema-based documents using an encoding based on the XML schema referenced by the document. Trying to insert or update a document that does not reference a registered XML schema or that does not conform to the XML schema it references raises an error.
`STORE AS BINARY XML ALLOW ANYSCHEMA ALLOW NONSCHEMA`	Encodes all XML schema-based documents using an encoding based on the XML schema referenced by the document. Encodes all non-schema-based documents using the non-schema-based encoding. Trying to insert or update an XML schema-based document that does not conform to the registered XML schema it references raises an error.

Note: If you use `CREATE TABLE` with `ALLOW NONSCHEMA` but not `ALLOW ANYSCHEMA`, then all documents, even XML schema-based documents, are encoded using the non-schema-based encoding. If you later use `ALTER TABLE` with `ALLOW ANYSCHEMA` on the same table, this has no effect on the encoding of documents that were stored prior to the `ALTER TABLE` operation—all such documents continue to be encoded using the non-schema-based encoding, regardless of whether they reference an XML schema. Only XML schema-based documents that you insert in the table after the `ALTER TABLE` operation are encoded using XML schema-based encodings.

Object-Relational Storage of XML Schema-Based Data

Suppose that you have registered a purchase-order XML schema, identified by URL `http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd`. You then create an object-relational `XMLType` table, `purchaseorder_as_table`, to store instances that conform to element `PurchaseOrder` of the XML schema, as in Example 17–8.

Example 17–8 Creating an Object-Relational XMLType Table with Default Storage

```
CREATE TABLE purchaseorder_as_table OF XMLType
   ELEMENT
   "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd#PurchaseOrder";
```

This automatically creates hidden columns that correspond to the database object type to which the `PurchaseOrder` element has been mapped. In addition, an `XMLEXTRA` object column is created, to store top-level instance data such as namespace declarations. `XMLEXTRA` is reserved for internal use.

Suppose that XML schema `purchaseOrder.xsd` defines element `LineItems` as a child of element `PurchaseOrder`, and that `LineItems` is a collection of `LineItem` elements.

With object-relational storage, collections are mapped to SQL varray values. An XML **collection** is any element that is defined by the XML schema with `maxOccurs` > 1, allowing it to appear multiple times. By default, the entire contents of such a varray is stored as a set of rows in an ordered collection table (OCT).

Example 17–9 creates table `purchaseorder_as_table` differently from Example 17–8. It specifies additional storage options:

- The `LineItems` collection varray is stored as a LOB, not as a table.
- Tablespace `USERS` is used for storing element `Notes`.
- The table is compressed for online transaction processing (OLTP).

Example 17–9 Specifying Object-Relational Storage Options for XMLType Tables and Columns

```
CREATE TABLE purchaseorder_as_table
  OF XMLType (UNIQUE ("XMLDATA"."Reference"),
              FOREIGN KEY ("XMLDATA"."User") REFERENCES hr.employees (email))
ELEMENT
  "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd#PurchaseOrder"
  VARRAY "XMLDATA"."LineItems"."LineItem" STORE AS LOB lineitem_lob
  LOB ("XMLDATA"."Notes")
    STORE AS (TABLESPACE USERS ENABLE STORAGE IN ROW
              STORAGE(INITIAL 4K NEXT 32K))
    COMPRESS FOR OLTP;

CREATE TABLE purchaseorder_as_column (
  id NUMBER,
  xml_document XMLType,
  UNIQUE (xml_document."XMLDATA"."Reference"),
  FOREIGN KEY (xml_document."XMLDATA"."User") REFERENCES hr.employees (email))
  XMLTYPE COLUMN xml_document
  XMLSCHEMA "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder"
  VARRAY xml_document."XMLDATA"."LineItems"."LineItem" STORE AS LOB lineitem_lob
  LOB (xml_document."XMLDATA"."Notes")
    STORE AS (TABLESPACE USERS ENABLE STORAGE IN ROW
              STORAGE(INITIAL 4K NEXT 32K))
    COMPRESS FOR OLTP;
```

Note: In releases prior to Oracle Database 11*g*R2, the default behavior for `CREATE TABLE` was to store a collection using a varray stored as a LOB, not a varray stored as a table.

Note: When compression is specified for a parent `XMLType` table or column, all descendant `XMLType` ordered collection tables (OCTs) are similarly compressed.

See Also:

- "Oracle XML Schema Annotations" on page 18-6 for information about specifying storage options by using XML schema annotations
- *Oracle Database SQL Language Reference* for information about compression for OLTP

As a convenience, if you need to specify that *all* varrays in an `XMLType` table or column are to be stored as LOBs, or all are to be stored as tables, then you can use the syntax clause `STORE ALL VARRAYS AS`, followed by `LOBS` or `TABLES`, respectively. This is a convenient alternative to using multiple `VARRAY...STORE AS` clauses, one for each collection. Example 17–10 illustrates this.

Example 17–10 Using STORE ALL VARRAYS AS

```
CREATE TABLE purchaseorder_as_table OF XMLType (UNIQUE ("XMLDATA"."Reference"),
  FOREIGN KEY ("XMLDATA"."User") REFERENCES hr.employees (email))
  ELEMENT
    "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd#PurchaseOrder"
  STORE ALL VARRAYS AS LOBS;
```

The storage method specified using `STORE ALL VARRAYS AS` overrides any storage method specified using (deprecated) XML Schema annotation `xdb:storeVarrayAsTable`[2] in the corresponding XML schema.

See Also: *Oracle Database SQL Language Reference* for information about using `STORE ALL VARRAYS AS LOBS`

Ways to Identify XML Schema Instance Documents

Before an XML document can be inserted into an XML schema-based `XMLType` table or column, the document must identify the associated XML schema. There are two ways to do this:

- Explicitly identify the XML schema when creating the `XMLType`. This can be done by passing the name of the XML schema to the `XMLType` constructor, or by invoking `XMLType` method `createSchemaBasedXML()`.
- Use the `XMLSchema-instance` mechanism to explicitly provide the required information in the XML document. This option can be used when working with Oracle XML DB.

The advantage of the `XMLSchema-instance` mechanism is that it lets the Oracle XML DB protocol servers recognize that an XML document inserted into Oracle XML DB Repository is an instance of a registered XML schema. The content of the instance document is automatically stored in the default table specified by that XML schema.

The `XMLSchema-instance` mechanism is defined by the W3C XML Schema working group. It is based on adding attributes that identify the target XML schema to the root element of the instance document. These attributes are defined by the `XMLSchema-instance` namespace.

[2] XML Schema annotation `xdb:storeVarrayAsTable` is *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1).

To identify an instance document as a member of the class defined by a particular XML schema you must declare the XMLSchema-instance namespace by adding a namespace declaration to the root element of the instance document. For example:

```
xmlns:xsi = http://www.w3.org/2001/XMLSchema-instance
```

Once the XMLSchema-instance namespace has been declared and given a namespace prefix, attributes that identify the XML schema can be added to the root element of the instance document. In the preceding example, the namespace prefix for the XMLSchema-instance namespace was defined as xsi. This prefix can then be used when adding the XMLSchema-instance attributes to the root element of the instance document.

Which attributes must be added depends on several factors. There are two possibilities, noNamespaceSchemaLocation and schemaLocation. Depending on the XML schema, one or both of these attributes is required to identify the XML schemas that the instance document is associated with.

Attributes noNamespaceSchemaLocation and schemaLocation

If the target XML schema does not declare a target namespace, the noNamespaceSchemaLocation attribute is used to identify the XML schema. The value of the attribute is the *schema location hint*. This is the unique identifier passed to PL/SQL procedure DBMS_XMLSCHEMA.registerSchema when the XML schema is registered with the database.

For XML schema purchaseOrder.xsd, the correct definition of the root element of the instance document would read as follows:

```
<PurchaseOrder
  xmlns:xsi=http://www.w3.org/2001/XMLSchema-instance
  xsi:noNamespaceSchemaLocation=
    "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
```

If the target XML schema declares a target namespace, then the schemaLocation attribute is used to identify the XML schema. The value of this attribute is a pair of values separated by a space:

- the value of the *target namespace* declared in the XML schema
- the *schema location hint*, the unique identifier passed to procedure DBMS_XMLSCHEMA.registerSchema when the schema is registered with the database

For example, assume that the PurchaseOrder XML schema includes a target namespace declaration. The root element of the schema would look like this:

```
<xs:schema targetNamespace="http://demo.oracle.com/xdb/purchaseOrder"
           xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0">
   <xs:element name="PurchaseOrder" type="PurchaseOrderType"
               xdb:defaultTable="PURCHASEORDER"/>
```

In this case, the correct form of the root element of the instance document would read as follows:

```
<PurchaseOrder
    xnlns="http://demo.oracle.com/xdb/purchaseOrder"
    xmlns:xsi=http://www.w3.org/2001/XMLSchema-instance
    xsi:schemaLocation=
      "http://demo.oracle.com/xdb/purchaseOrder
       http://mdrake-lap:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
```

XML Schema and Multiple Namespaces

When an XML schema includes elements defined in multiple namespaces, an entry must occur in the `schemaLocation` attribute for each of the XML schemas. Each entry consists of the namespace declaration and the *schema location hint*. The entries are separated from each other by one or more whitespace characters. If the primary XML schema does not declare a target namespace, then the instance document also needs to include a `noNamespaceSchemaLocation` attribute that provides the *schema location hint* for the primary XML schema.

XML Schema Data Types Are Mapped to Oracle XML DB Storage

XML data that conforms to an XML schema is typed using XML Schema data types. When this XML data is stored in Oracle XML DB, its storage data types are derived from the XML Schema data types using a default mapping and, optionally, using mapping information that you specify using XML schema annotations.

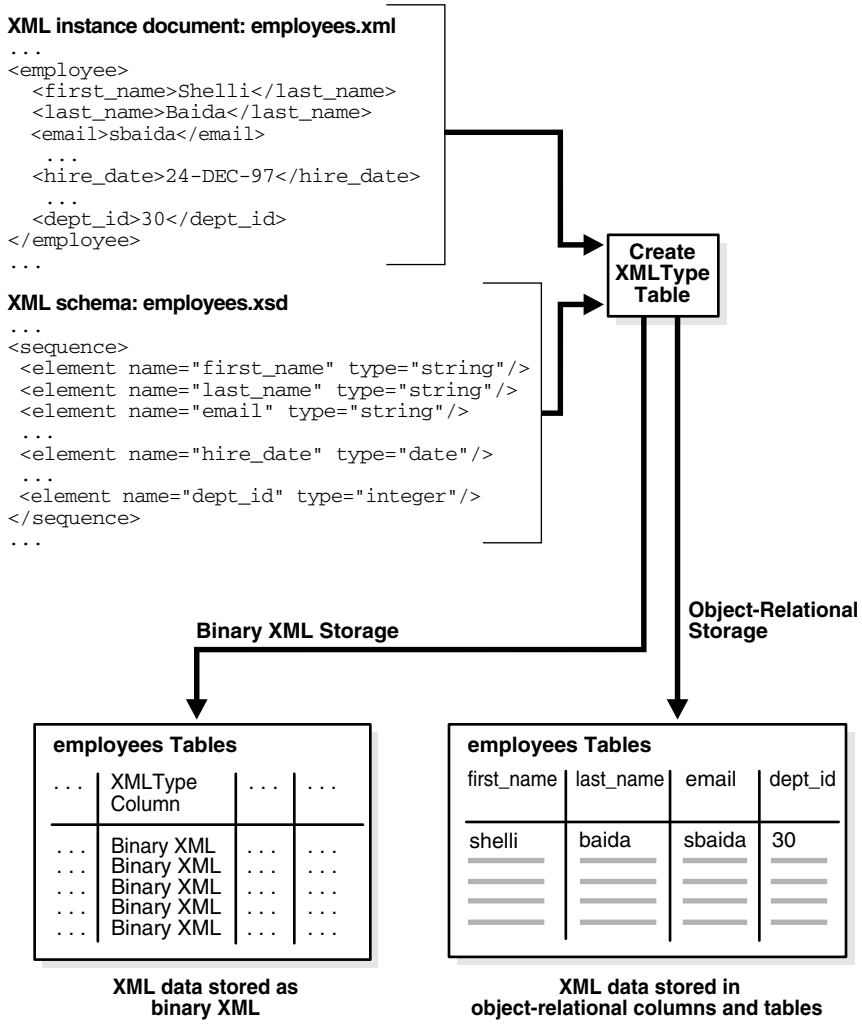
Whenever you do not specify a data type to use for storage, Oracle XML DB uses the default mapping to annotate the XML schema appropriately, during registration. In this way, the registered XML schema has a complete set of data-type annotations.

- For object-relational storage, XML Schema data types are mapped to SQL data types.
- For binary XML storage, XML Schema data types are mapped to Oracle XML DB binary XML encoding types.

> **See Also:** "How to Map XML Schema Data Types to SQL Data Types" on page 18-17

Figure 17–7 shows how Oracle XML DB creates XML schema-based `XMLType` tables using an XML document and a mapping specified in an XML schema. Depending on the storage method specified in the XML schema, an XML instance document is stored either as a binary XML value in a single `XMLType` column, or using multiple object-relational columns.

Figure 17–7 How Oracle XML DB Maps XML Schema-Based XMLType Tables



18

XML Schema Storage and Query: Object-Relational Storage

This chapter describes advanced techniques for storing structured XML schema-based `XMLType` objects.

This chapter contains these topics:

See Also:

- Chapter 17, "XML Schema Storage and Query: Basic" for basic information about using XML Schema with Oracle XML DB
- Chapter 19, "XPath Rewrite for Object-Relational Storage" for information about the optimization of XPath expressions in Oracle XML DB
- Chapter 20, "XML Schema Evolution" for information about updating an XML schema after you have registered it with Oracle XML DB
- `http://www.w3.org/TR/xmlschema-0/` for an introduction to XML Schema

Object-Relational Storage of XML Documents

Object-relational storage of XML documents is based on decomposing the document content into a set of SQL objects. These SQL objects are based on the SQL 1999 Type framework. When an XML schema is registered with Oracle XML DB, the required SQL type definitions are automatically generated from the XML schema.

A SQL type definition is generated from each `complexType` defined by the XML schema. Each element or attribute defined by the `complexType` becomes a SQL attribute in the corresponding SQL type. Oracle XML DB automatically maps the 47 scalar data types defined by the XML Schema Recommendation to the 19 scalar data types supported by SQL. A varray type is generated for each element and this can occur multiple times.

The generated SQL types allow XML content that is compliant with the XML schema to be decomposed and stored in the database as a set of objects, without any loss of information. When an XML document is ingested, the constructs defined by the XML schema are mapped directly to the equivalent SQL types. This lets Oracle XML DB leverage the full power of Oracle Database when managing XML, and it can lead to significant reductions in the amount of space required to store the document. It can also reduce the amount of memory required to query and update XML content.

How Collections Are Stored for Object-Relational XMLType Storage

When you register an XML schema for data that is stored object-relationally and you set registration parameter `GENTABLES` to `TRUE`, default tables are created automatically to store the associated XML instance documents.

Order is preserved among XML collection elements when they are stored. The result is an **ordered collection**.[1] You can store data in an ordered collection in these ways:

- **Varray in a table**. Each element in the collection is mapped to a SQL object. The collection of SQL objects is stored as a set of rows in a table, called an **ordered collection table** (**OCT**). By default, all collections are stored in OCTs.

  This default behavior corresponds to the XML schema annotation `xdb:storeVarrayAsTable = "true"` (default value).[2]

- **Varray in a LOB (deprecated)**. Each element in the collection is mapped to a SQL object. The entire collection of SQL objects is serialized as a varray and stored in a LOB column. To store a given collection as a varray in a LOB, use XML schema annotation `xdb:storeVarrayAsTable = "false"`.[2]

You can also use out-of-line storage for an ordered collection. This corresponds to XML schema annotation `SQLInline = "false"`, and it means that a varray of `REF`s in the collection table or LOB tracks the collection content, which is stored out of line.

There is no requirement to annotate an XML schema before using it. Oracle XML DB uses a set of default assumptions when processing an XML schema that contains no annotations.

If you do not supply any of the annotations mentioned in this section, then Oracle XML DB stores a collection as a *heap-based* OCT. You can force OCTs to be stored as **index-organized tables** (**IOTs**) instead, by passing **`REGISTER_NT_AS_IOT`** in the `OPTIONS` parameter of `DBMS_XMLSCHEMA.registerSchema`.

[1] XML Schema annotation `xdb:maintainOrder` is *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1). If you use `xdb:maintainOrder = "false"`, then an unordered collection is used instead of an ordered collection. Oracle recommends that you use ordered collections (`xdb:maintainOrder = "true"`) for XML data, to preserve document order. By default, attribute `xdb:maintainOrder` is `true`.

[2] XML Schema annotation `xdb:storeVarrayAsTable` is *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1).

Note: In releases prior to Oracle Database 11g Release 1:

- OCTs were stored as IOTs by default.
- The default value for `xdb:storeVarrayAsTable` was `false`.

Note: Use heap-based OCTs, *not* IOTs, unless you are explicitly advised by Oracle to use IOTs. IOT storage has these significant limitations:

- It disables partitioning of the collection tables (IOTs).
- It supports only document-level Oracle Text indexes. It disables indexes that are element-specific or attribute-specific.

See also: Appendix E, "Full-Text Search over XML Data Without XQuery" for information about using Oracle Text with XML data.

See Also:

- "Object-Relational Storage of XML Documents" on page 18-1 for information about collection storage when you create `XMLType` tables and columns manually using object-relational storage
- "Setting Annotation Attribute xdb:SQLInline to false for Out-Of-Line Storage" on page 18-36
- Partitioning of XMLType Tables and Columns Stored Object-Relationally on page 18-30

SQL Types Created during XML Schema Registration for Object-Relational Storage

Use `TRUE` as the value of parameter `GENTYPES` when you register an XML schema for use with XML data stored object-relationally (`TRUE` is the default value). Oracle XML DB then creates the appropriate SQL object types that enable object-relational storage of conforming XML documents.

By default, all SQL object types are created in the database schema of the user who registers the XML schema. If annotation `xdb:defaultSchema` is used, then Oracle XML DB attempts to create the object type using the specified database schema. The current user must have the necessary privileges to create these object types.

Example 18–1 shows the SQL object types that are created automatically when XML schema `purchaseOrder.xsd` is registered with Oracle XML DB.

Example 18–1 SQL Object Types for Storing XMLType Tables

```
DESCRIBE "PurchaseOrderType1668_T"

"PurchaseOrderType1668_T" is NOT FINAL
Name                 Null?  Type
-------------------- ------ --------------------------------
SYS_XDBPD$                  XDB.XDB$RAW_LIST_T
Reference                   VARCHAR2(30 CHAR)
Actions                     ActionsType1661_T
Reject                      RejectionType1660_T
Requestor                   VARCHAR2(128 CHAR)
```

```
User                          VARCHAR2(10 CHAR)
CostCenter                    VARCHAR2(4 CHAR)
ShippingInstructions          ShippingInstructionsTyp1659_T
SpecialInstructions           VARCHAR2(2048 CHAR)
LineItems                     LineItemsType1666_T
Notes                         VARCHAR2(4000 CHAR)

DESCRIBE "LineItemsType1666_T"

"LineItemsType1666_T" is NOT FINAL
Name                  Null? Type
--------------------- ----- ------------------------------
SYS_XDBPD$                  XDB.XDB$RAW_LIST_T
LineItem                    LineItem1667_COLL

DESCRIBE "LineItem1667_COLL"

"LineItem1667_COLL" VARRAY(2147483647) OF LineItemType1665_T
"LineItemType1665_T" is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
ItemNumber                 NUMBER(38)
Description                VARCHAR2(256 CHAR)
Part                       PartType1664_T
```

Note: By default, the names of the SQL object types and attributes are system-generated. This is the case in Example 18–1. If the XML schema does not contain attribute `SQLName`, then the SQL name is derived from the XML name. You can use XML schema annotations to provide user-defined names (see "Oracle XML Schema Annotations" on page 18-6 for details).

Default Tables Created during XML Schema Registration

As part of XML schema registration for XML data, you can create default tables. Default tables are most useful when documents conforming to the XML schema are inserted through APIs and protocols such as FTP and HTTP(S) that do not provide any table specification. In such cases, the XML instance is inserted into the default table.

Example 18–2 describes the default purchase-order table.

Example 18–2 Default Table for Global Element PurchaseOrder

```
DESCRIBE "PurchaseOrder1669_TAB"

Name                          Null? Type
----------------------------- ----- -----------------------
TABLE of
  SYS.XMLTYPE(
    XMLSchema "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
    Element "PurchaseOrder")
  STORAGE OBJECT-RELATIONAL TYPE "PurchaseOrderType1668_T"
```

If you provide a value for attribute `xdb:defaultTable`, then the `XMLType` table is created with that name. Otherwise it is created with an internally generated name.

Any text specified using attributes `xdb:tableProps` and `xdb:columnProps` is appended to the generated `CREATE TABLE` statement.

Do Not Use Internal Constructs Generated during XML Schema Registration

In general, the SQL constructs generated during XML schema registration are *internal* to Oracle XML DB. Oracle recommends that you do *not* use them in your code.

More precisely, generated SQL data types, nested tables, and tables associated with out-of-line storage are all internal. They are based on specific XML schema-to-object type mappings that are subject to change and redefinition by Oracle at any time.

In general:

- Do not use any generated SQL data types.
- Do not access or modify any generated nested tables or out-of-line tables.

You can, however, modify the storage options, such as partitioning, of generated tables, and you can create indexes and constraints on generated tables. You can also freely use any XML schema annotations provided by Oracle XML DB, including to name generated constructs for your convenience.

Generated Names are Case Sensitive

The names of any SQL tables, object, and attributes generated by XML schema registration are *case sensitive*. For instance, in Example 18–2 on page 18-4, the name of table `PurchaseOrder1669_TAB` is derived from the name of element `PurchaseOrder`, so it too is mixed case. You must therefore refer to this table using a quoted identifier: `"PurchaseOrder1669_TAB"`. Failure to do so results in an object-not-found error, such as `ORA-00942: table or view does not exist`.

SYS_XDBPD$ and DOM Fidelity for Object-Relational Storage

With object-relational storage of XML data, the elements and attributes declared in an XML schema are mapped to separate attributes in the corresponding SQL object types. However, the following information in XML instance documents is not stored in these object attributes:

- Namespace declarations
- Comments
- Prefix information

In order to provide DOM fidelity for XML data stored object-relationally, Oracle XML DB uses a separate mechanism to keep track of this information: it is recorded as instance-level metadata.

This metadata is tracked at the type level using the system-defined binary object attribute `SYS_XDBPD$`. This object attribute is referred to as the **positional descriptor**, or **PD** for short. The PD is intended for Oracle XML DB *internal use only*. You should never directly access or manipulate column PD.

The positional descriptor stores all information that cannot be stored in any of the other object attributes. PD information is used to ensure the DOM fidelity of all XML documents stored in Oracle XML DB. Examples of PD information include: ordering information, comments, processing instructions, and namespace prefixes.

If DOM fidelity is not required, you can suppress the use of `SYS_XDBPD$` by setting attribute `xdb:maintainDOM` to `false` in the XML schema, at the type level.

Note: For clarity, object attribute `SYS_XDBPD$` is omitted in many examples in this book. However, it is always present as a positional descriptor (PD) column in all SQL object types that are generated by the XML schema registration process.

In general, Oracle recommends that you do not suppress the PD attribute, because the extra information, such as comments and processing instructions, could be lost if there is no PD column.

See Also:

- "Overriding the SQLType Value in an XML Schema When Declaring Attributes" on page 18-19
- "Override of the SQLType Value in an XML Schema When Declaring Elements" on page 18-20
- "DOM Fidelity" on page 17-6 for information about DOM fidelity and binary XML storage of XML data

Oracle XML Schema Annotations

You can annotate XML schemas to influence the objects and tables that are generated by the XML schema registration process. You do this by adding Oracle-specific attributes to `complexType`, `element`, and `attribute` definitions that are declared by the XML schema.

You can add such annotations manually by editing the XML schema document or, for the most common annotations, by invoking annotation-specific PL/SQL subprograms. See *Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSCHEMA_ANNOTATE".

If you edit an XML schema manually using the Altova XMLSpy editor then you can take advantage of the *Oracle* tab in the editor for adding and editing Oracle-specific annotations. See Figure 17–2, "XMLSpy Support for Oracle XML DB Schema Annotations" on page 17-6.

Most XML attributes used by Oracle XML DB belong to the namespace `http://xmlns.oracle.com/xdb`. XML attributes used for encoding XML data as binary XML belong to the namespace `http://xmlns.oracle.com/2004/CSX`. To simplify the process of annotating an XML schema, Oracle recommends that you declare namespace prefixes in the root element of the XML schema.

Common Uses of XML Schema Annotations

Common reasons for wanting to annotate an XML schema include the following:

- To ensure that the names of the tables, objects, and object attributes created by PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema` for object-relational storage of `XMLType` data are easy to recognize and compliant with any application-naming standards. Set parameter `GENTYPES` or `GENTABLES` to `TRUE` for this (`TRUE` is the default value for each of these parameters).
- To prevent the generation of mixed-case names that require the use of quoted identifiers when working directly with SQL.
- To allow XPath rewrite for object-relational storage in the case of document-correlated recursive XPath queries. This applies to certain applications

of SQL/XML access and query functions whose XQuery-expression argument targets recursive XML data.

The most commonly used XML schema annotations are the following:

- `xdb:defaultTable` – Name of the default table generated for each global element when parameter `GENTABLES` is `TRUE`. Setting this to the empty string, **`""`**, prevents a default table from being generated for the element in question.
- `xdb:SQLName` – Name of the SQL object attribute that corresponds to each element or attribute defined in the XML schema.
- `xdb:SQLType` – For `complexType` definitions, the corresponding object type. For `simpleType` definitions, `SQLType` is used to override the default mapping between XML schema data types and SQL data types. A common use of `SQLType` is to define when unbounded strings should be stored as `CLOB` values, rather than as `VARCHAR(4000) CHAR` values (the default). Note: You cannot use data type `NCHAR`, `NVARCHAR2`, or `NCLOB` as the value of a `SQLType` annotation.
- `xdb:SQLCollType` – Used to specify the varray type that manages a collection of elements.
- `xdb:maintainDOM` – Used to determine whether or not DOM fidelity should be maintained for a given `complexType` definition

You need not specify values for any of these attributes. Oracle XML DB provides appropriate values by default during the XML schema registration process. However, if you are using object-relational storage, then Oracle recommends that you specify the names of at least the top-level SQL types, so that you can reference them later.

XML Schema Annotation Example

Example 18–3 shows an XML schema that is modified to include some of the most important Oracle XML DB annotations. This XML schema is similar to the one in Example A–2 on page A-34, but it also defines a `Notes` element and its type, `NotesType`.

Example 18–3 Using Common Schema Annotations

```
<xs:schema
  targetNamespace="http://xmlns.oracle.com/xdb/documentation/purchaseOrder"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:xdb="http://xmlns.oracle.com/xdb"
  xmlns:po="http://xmlns.oracle.com/xdb/documentation/purchaseOrder"
  version="1.0">
  <xs:element name="PurchaseOrder" type="po:PurchaseOrderType"
              xdb:defaultTable="PURCHASEORDER"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Reference" type="po:ReferenceType" minOccurs="1"
                  xdb:SQLName="REFERENCE"/>
      <xs:element name="Actions" type="po:ActionsType"
                  xdb:SQLName="ACTION_COLLECTION"/>
      <xs:element name="Reject" type="po:RejectionType" minOccurs="0"/>
      <xs:element name="Requestor" type="po:RequestorType"/>
      <xs:element name="User" type="po:UserType" minOccurs="1"
                  xdb:SQLName="EMAIL"/>
      <xs:element name="CostCenter" type="po:CostCenterType"/>
      <xs:element name="ShippingInstructions"
                  type="po:ShippingInstructionsType"/>
      <xs:element name="SpecialInstructions" type="po:SpecialInstructionsType"/>
```

```
      <xs:element name="LineItems" type="po:LineItemsType"
                  xdb:SQLName="LINEITEM_COLLECTION"/>
      <xs:element name="Notes" type="po:NotesType" xdb:SQLType="CLOB"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="po:LineItemType" maxOccurs="unbounded"
                  xdb:SQLCollType="LINEITEM_V" xdb:SQLName="LINEITEM_VARRAY"/>
   </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Description" type="po:DescriptionType"/>
      <xs:element name="Part" type="po:PartType"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T" xdb:maintainDOM="false">
    <xs:attribute name="Id">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:minLength value="10"/>
          <xs:maxLength value="14"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
    <xs:attribute name="Quantity" type="po:moneyType"/>
    <xs:attribute name="UnitPrice" type="po:quantityType"/>
  </xs:complexType>
  <xs:simpleType name="NotesType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="32767"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

- The `schema` element includes the declaration of the `xdb` namespace.
- The definition of global element `PurchaseOrder` includes a `defaultTable` annotation that specifies that the name of the default table associated with this element is `purchaseorder`.
- The definition of global complex type `PurchaseOrderType` includes a `SQLType` annotation that specifies that the generated SQL object type is named `purchaseorder_t`. Within the definition of this type, the following annotations are used:
  - The definition of element `Reference` includes a `SQLName` annotation that specifies that the SQL attribute corresponding to XML element `Reference` is named `reference`.
  - The definition of element `Actions` includes a `SQLName` annotation that specifies that the SQL attribute corresponding to XML element `Actions` is named `action_collection`.
  - The definition of element `USER` includes a `SQLName` annotation that specifies that the SQL attribute corresponding to XML element `User` is named `email`.

    - The definition of element `LineItems` includes a `SQLName` annotation that specifies that the SQL attribute corresponding to XML element `LineItems` is named `lineitem_collection`.
    - The definition of element `Notes` includes a `SQLType` annotation that specifies that the data type of the SQL attribute corresponding to XML element `Notes` is `CLOB`.
- The definition of global complex type `LineItemsType` includes a `SQLType` annotation that specifies that the generated SQL object type is named `lineitems_t`. Within the definition of this type, the following annotation is used:
    - The definition of element `LineItem` includes a `SQLName` annotation that specifies that the data type of the SQL attribute corresponding to XML element `LineItems` is named `lineitem_varray`, and a `SQLCollName` annotation that specifies that the SQL object type that manages the collection is named `lineitem_v`.
- The definition of global complex type `LineItemType` includes a `SQLType` annotation that specifies that generated SQL object type is named `lineitem_t`.
- The definition of complex type `PartType` includes a `SQLType` annotation that specifies that the SQL object type is named `part_t`. It also includes the annotation `xdb:maintainDOM = "false"`, specifying that there is no need for Oracle XML DB to maintain DOM fidelity for elements based on this data type.

Example 18–4 shows some of the tables and objects that are created when the annotated XML schema of Example 18–3 is registered.

Example 18–4 Registering an Annotated XML Schema

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    SCHEMADOC => bfilename('XMLDIR', 'purchaseOrder.Annotated.xsd'),
    LOCAL     => TRUE,
    GENTYPES  => TRUE,
    GENTABLES => TRUE,
    CSID      => nls_charset_id('AL32UTF8'));
END;
/

SELECT table_name, xmlschema, element_name FROM USER_XML_TABLES;

TABLE_NAME     XMLSCHEMA                              ELEMENT_NAME
-------------  -----------------------------------    -------------
PURCHASEORDER  http://xmlns.oracle.com/xdb/documen    PurchaseOrder
               tation/purchaseOrder.xsd

1 row selected.

DESCRIBE purchaseorder

Name                           Null? Type
-----------------------------  ----- -----------------
TABLE of SYS.XMLTYPE(XMLSchema
 "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
 ELEMENT "PurchaseOrder") STORAGE Object-relational TYPE "PURCHASEORDER_T"

DESCRIBE purchaseorder_t
```

```
PURCHASEORDER_T is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
REFERENCE                  VARCHAR2(30 CHAR)
ACTION_COLLECTION          ACTIONS_T
REJECT                     REJECTION_T
REQUESTOR                  VARCHAR2(128 CHAR)
EMAIL                      VARCHAR2(10 CHAR)
COSTCENTER                 VARCHAR2(4 CHAR)
SHIPPINGINSTRUCTIONS       SHIPPING_INSTRUCTIONS_T
SPECIALINSTRUCTIONS        VARCHAR2(2048 CHAR)
LINEITEM_COLLECTION        LINEITEMS_T
Notes                      CLOB

DESCRIBE lineitems_t
LINEITEMS_T is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
LINEITEM_VARRAY            LINEITEM_V

DESCRIBE lineitem_v

LINEITEM_V VARRAY(2147483647) OF LINEITEM_T
LINEITEM_T is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
ITEMNUMBER                 NUMBER(38)
DESCRIPTION                VARCHAR2(256 CHAR)
PART                       PART_T

DESCRIBE part_t

PART_T is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------
ID                         VARCHAR2(14 CHAR)
QUANTITY                   NUMBER(12,2)
UNITPRICE                  NUMBER(8,4)

SELECT table_name, parent_table_column FROM USER_NESTED_TABLES
  WHERE parent_table_name = 'purchaseorder';

TABLE_NAME                     PARENT_TABLE_COLUMN
----------                     -----------------------
SYS_NTNOHV+tfSTRaDTA9FETvBJw==   "XMLDATA"."LINEITEM_COLLECTION"."LINEITEM_VARRAY"
SYS_NTV4bNVqQ1S4WdCIvBK5qjZA==   "XMLDATA"."ACTION_COLLECTION"."ACTION_VARRAY"

2 rows selected.
```

The following are results of this XML schema registration:

- A table called `purchaseorder` was created.
- Types called `purchaseorder_t`, `lineitems_t`, `lineitem_v`, `lineitem_t`, and `part_t` were created. The attributes defined by these types are named according to supplied the `SQLName` annotations.
- The `Notes` attribute defined by `purchaseorder_t` is of data type `CLOB`.

- Type `part_t` does not include a positional descriptor (PD) attribute.
- Ordered collection tables (OCTs) were created to manage the collections of `LineItem` and `Action` elements.

Annotating an XML Schema Using DBMS_XMLSCHEMA_ANNOTATE

PL/SQL package `DBMS_XMLSCHEMA_ANNOTATE` provides subprograms to annotate an XML schema. Using these subprograms can often be more convenient and less error prone than manually editing the XML schema.

In particular, you can use the PL/SQL subprograms in a script, which you can run at any time or multiple times, as needed. This can be especially useful if you are using a large XML schema or a standard or other third-party XML schema that you do not want to modify manually.

There are specific PL/SQL subprograms for each Oracle annotation. For example, you use PL/SQL procedure `setDefaultTable` to add a `xdb:defaultTable` annotation, and `removeDefaultTable` to remove a `xdb:defaultTable` annotation.

Each annotation subprogram has the following as its parameters:

- The XML schema to be annotated. This parameter is `IN OUT`.
- The name of the global element where the annotation is to be added or removed.
- The annotation (XML attribute) value.
- A Boolean flag indicating whether any corresponding existing annotation is to be overwritten. By default, it is overwritten.

If the element to be annotated is not a global element then you provide the local element name as an additional parameter. The global and local names together identify the target element. The element with the local name must be a descendent of the element with the global name.

If you use SQL*Plus, you can use PL/SQL procedure `DBMS_XMLSCHEMA_ANNOTATE.printWarnings` to enable and disable printing of SQL*Plus warnings during the use of other `DBMS_XMLSCHEMA_ANNOTATE` subprograms. By default, no warnings are printed. An example of a warning is an inability to annotate the XML schema because there is no element with the name you provided to the annotation subprogram.

Example 18–5 uses subprograms in PL/SQL package `DBMS_XMLSCHEMA_ANNOTATE` to produce the annotated XML schema shown in Example 18–3.

Example 18–5 Using DBMS_XMLSCHEMA_ANNOTATE

```
CREATE TABLE annotation_tab (id NUMBER, inp XMLType, out XMLType);
INSERT INTO annotation_tab VALUES (1, ... unannotated XML schema...);

DECLARE
  schema XMLType;
BEGIN
  SELECT t.inp INTO schema FROM annotation_tab t WHERE t.id = 1;

  DBMS_XMLSCHEMA_ANNOTATE.setDefaultTable(schema, 'PurchaseOrder', 'PURCHASEORDER');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLType(schema, 'PurchaseOrderType', 'PURCHASEORDER_T');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLName(schema, 'complexType', 'PurchaseOrderType', 'element', 'Reference',
                                     'REFERENCE');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLName(schema, 'complexType', 'PurchaseOrderType', 'element', 'Actions',
                                     'ACTIONS_COLLECTION');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLName(schema, 'complexType', 'PurchaseOrderType', 'element', 'User', 'EMAIL');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLName(schema, 'complexType', 'PurchaseOrderType', 'element', 'LineItems',
                                     'LINEITEM_COLLECTION');
```

```
  DBMS_XMLSCHEMA_ANNOTATE.setSQLType(schema, 'complexType', 'PurchaseOrderType', 'element', 'Notes', 'CLOB');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLType(schema, 'LineItemsType', 'LINEITEMS_T');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLCollType(schema, 'complexType', 'LineItemsType', 'LineItem', 'LINEITEM_V');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLName(schema, 'complexType', 'LineItemsType', 'element', 'LineItem',
                                     'LINEITEM_VARRAY');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLType(schema, 'LineItemType', 'LINEITEM_T');
  DBMS_XMLSCHEMA_ANNOTATE.setSQLType(schema, 'PartType', 'PART_T');
  DBMS_XMLSCHEMA_ANNOTATE.disableMaintainDom(schema, 'PartType');

UPDATE annotation_tab t SET t.out = schema WHERE t.id = 1;
END;
/
```

See Also: *Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSCHEMA_ANNOTATE"

Available Oracle XML DB XML Schema Annotations

Table 18–1, Table 18–2, and Table 18–3 list Oracle XML DB annotations that you can specify in element and attribute declarations. These tables also list the PL/SQL subprograms in package `DBMS_XMLSCHEMA_ANNOTATE` that you can use to manipulate the corresponding annotations.

All annotations except those that have the prefix `csx` are applicable to XML schemas registered for object-relational storage.

The following annotations apply to XML schemas that are registered for binary XML storage:

- `xdb:defaultTable`
- `xdb:defaultTableSchema` (deprecated)
- `xdb:tableProps`

See Also: *Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSCHEMA_ANNOTATE"

Table 18–1 Annotations in Elements

Attribute and PL/SQL	Values	Default	Description
`xdb:columnProps` No applicable PL/SQL.	Any column storage clause	`NULL`	Specifies the `COLUMN` storage clause that is inserted into the default `CREATE TABLE` statement. It is useful mainly for elements that get mapped to SQL tables, namely top-level element declarations and out-of-line element declarations.

`xdb:defaultTable`
PL/SQL:
`setDefaultTable`
`removeDefaultTable`
`enableDefaultTableCreation`
`disableDefaultTableCreation`
	Any table name	Based on element name	Specifies the name of the SQL table into which XML instances of this XML schema are stored. This is most useful in cases where the XML data is inserted from APIs and protocols, such as FTP and HTTP(S), where the table name is not specified. Applicable to object-relational storage and binary XML storage.

`xdb:defaultTableSchema`[1] *Deprecated*. No applicable PL/SQL.	Any SQL user name	User registering XML schema	Name of the database user (database schema) who owns the type specified by `xdb:defaultTable`. Applicable to object-relational storage and binary XML storage.

Table 18–1 (Cont.) Annotations in Elements

Attribute and PL/SQL	Values	Default	Description

`xdb:maintainDOM`
PL/SQL:
`enableMaintainDOM`
`disableMaintainDOM`
	`true` | `false`	`true`	If `true`, then instances of this element are stored so that they retain DOM fidelity on output. This implies that all comments, processing instructions, namespace declarations, and so on are retained, in addition to the ordering of elements.
			If `false`, then the output is not guaranteed to have the same DOM action as the input.

`xdb:maintainOrder`[1] *Deprecated*. No applicable PL/SQL.	`true` | `false`	`true`	If `true` (generally recommended, and the default value), then the collection is mapped to a varray (stored in a LOB or an ordered collection table). If `false`, then the collection is mapped to an unordered table, and document order is *not* preserved.
`xdb:SQLCollSchema`[1] *Deprecated*. No applicable PL/SQL.	Any SQL user name	User registering XML schema	Name of the database user (database schema) who owns the type specified by `xdb:SQLCollType`.

`xdb:SQLCollType`
PL/SQL:
`setSQLCollType`
`removeSQLCollType`
	Any SQL collection type	Name generated from element name	Name of the SQL collection type that corresponds to this XML element. The XML element must be specified with `maxOccurs` > 1.

`xdb:SQLInline`
PL/SQL:
`setOutOfLine`
`removeOutOfLine`
	`true` | `false`	`true`	If `true`, then this element is stored inline as an embedded object attribute (or as a collection, if `maxOccurs` > 1).
			If `false`, then a `REF` value is stored (or a collection of `REF` values, if `maxOccurs` > 1). This attribute is forced to `false` in certain situations, such as cyclic references, where SQL does not support inlining.

`xdb:SQLName`
PL/SQL:
`setSQLName`
`removeSQLName`
	Any SQL identifier	Element name	Name of the attribute within the SQL object that maps to this XML element.

`xdb:SQLSchema`[1] *Deprecated*. No applicable PL/SQL.	Any SQL user name	User registering XML schema	Name of the database user (database schema) who owns the type specified by `SQLType`.

`xdb:SQLType`
PL/SQL:
`setSQLType`
`removeSQLType`
	Any SQL data type[2], *except* `NCHAR`, `NVARCHAR2`, and `NCLOB`	Name generated from element name	Name of the SQL type corresponding to this XML element declaration.

`xdb:tableProps`
PL/SQL:
`setTableProps`
`removeTableProps`
	Any table storage clause	`NULL`	Specifies the `TABLE` storage clause that is appended to the default `CREATE TABLE` statement. This is meaningful mainly for global and out-of-line elements. Applicable to object-relational storage and binary XML storage.

[1] XML Schema annotations `xdb:defaultTableSchema`, `xdb:maintainOrder`, `xdb:SQLCollSchema`, and `xdb:SQLSchema` are *deprecated*, starting with Oracle Database Release 12*c* (12.1.0.1).

[2] See "How to Map XML Schema Data Types to SQL Data Types" on page 18-17.

See Also: "Object-Relational Storage of XML Schema-Based Data" on page 17-20 for information about specifying storage options when manually creating `XMLType` tables for object-relational storage

Table 18–2 Annotations in Elements Declaring Global complexType Elements

Attribute	Values	Default	Description

`xdb:maintainDOM`
PL/SQL:
`enableMaintainDom`
`disableMaintainDom`
	`true` | `false`	`true`	If `true`, then instances of this element are stored so that they retain DOM fidelity on output. This implies that all comments, processing instructions, namespace declarations, and so on are retained, in addition to the ordering of elements.
			If `false`, then the output is not guaranteed to have the same DOM action as the input.

`xdb:SQLSchema`[1] *Deprecated*. No applicable PL/SQL.	Any SQL user name	User registering XML schema	Name of the database user (database schema) who owns the type specified by `SQLType`.

`xdb:SQLType`
PL/SQL:
`setSQLType`
`removeSQLType`
	Any SQL data type[2] *except* `NCHAR`, `NVARCHAR2`, and `NCLOB`	Name generated from element name	Name of the SQL type that corresponds to this XML element declaration.

[1] XML Schema annotation `xdb:SQLSchema` is *deprecated*, starting with Oracle Database Release 12*c* (12.1.0.1).

[2] See "How to Map XML Schema Data Types to SQL Data Types" on page 18-17.

Table 18–3 Annotations in XML Schema Declarations

Attribute	Values	Default	Description
`xdb:mapUnboundedStringToLob`[1] No applicable PL/SQL.	`true` | `false`	`false`	If `true`, then unbounded strings are mapped to `CLOB` instances by default. Similarly, unbounded binary data gets mapped to a `BLOB` value, by default. If `false`, then unbounded strings are mapped to `VARCHAR2(4000)` values, and unbounded binary components are mapped to `RAW(2000)` values.
`xdb:storeVarrayAsTable`[1] *Deprecated*. No applicable PL/SQL.	`true` | `false`	`true`	If `true`, then the varray is stored as a table (OCT). The default value is `true`. If `false`, then the varray is stored in a LOB.

[1] XML Schema annotations `xdb:mapUnboundedStringToLob` and `xdb:storeVarrayAsTable` are *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1).

XML Schema Annotation Guidelines for Object-Relational Storage

For `XMLType` data stored object-relationally, careful planning is called for, to optimize performance. Similar considerations are in order as for ordinary relational data: the entity-relationship model, indexing, data types, table partitions, and so on.

To enable XPath rewrite and achieve optimal performance, you implement many such design choices using XML schema annotations. This section provides annotation guidelines to optimize the use of `XMLType` data stored object-relationally.

See Also:

- Table 18–1, " Annotations in Elements" on page 18-12
- Chapter 19, "XPath Rewrite for Object-Relational Storage"

Avoid Creation of Unnecessary Tables for Unused Top-Level Elements

By default, XML schema registration creates a top-level table for each top-level element defined in the XML schema. Some such elements are used as top-level elements in XML instances that conform to the XML schema. Others might not be. It is common, for example, for elements in an XML schema to be top-level in order to be used as a `REF` target.

Whenever a top-level element in an XML schema is *never* used at the top level in any corresponding XML instance, you can avoid the creation of the associated unnecessary tables by adding annotation `xdb:defaultTable = ""` to the element in the XML schema. An empty value for this attribute prevents default-table creation.

You can use PL/SQL procedure `DBMS_XMLSCHEMA_ANNOTATE.disableDefaultTableCreation` to accomplish this. It adds an empty `xdb:defaultTable` attribute to each top-level element that has no `xdb:defaultTable` attribute.

Note: Any top-level XML schema element that is used as the root element of any instance documents must have a non-empty `xdb:defaultTable` attribute.

See Also: *Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSCHEMA_ANNOTATE" for information about PL/SQL procedure `disableDefaultTableCreation`.

Provide Your Own Names for Default Tables

For tuning purposes, you examine execution plan output for queries you are interested in. This output refers to the tables that underlie `XMLType` data stored object-relationally. By default, these tables have system-generated names. Oracle recommends that you provide your own table names, especially for tables that you are sure to be interested in. You do that using annotation `xdb:defaultTable`.

See Also: "Default Tables Created during XML Schema Registration" on page 18-4

Turn Off DOM Fidelity If Not Needed

By default, XML schema registration generates tables that store XML data in such a way that DOM fidelity is maintained. It is often the case that for data-centric XML data DOM fidelity is not needed. You can improve the performance of storage, queries, and data modification by instead using object-relational tables that do not maintain DOM fidelity. You use the annotation `xdb:maintainDOM = "false"` to do that.

See Also: "DOM Fidelity" on page 17-6

Annotate Time-Related Elements with a Timestamp Data Type

If your application needs to work with time-zone indicators, then annotate any XML schema elements of type `xs:time` and `xs:dateTime` with `xdb:SQLType = "TIMESTAMP WITH TIME ZONE"`. This ensures that values containing time-zone indicators can be

stored, retrieved, and compared.

Add Table and Column Properties

If a table or column underlying XML data needs additional properties, such as partition, tablespace, or compression clauses, then use annotation `xdb:tableProps` or `xdb:columnProps` to provide them. This lets users add primary keys or constraints. For example, to achieve table compression for online transaction processing (OLTP), you would add `COMPRESS FOR OLTP` using a `tableProps` attribute.

> **See Also:** Example 17–9 on page 17-21 for an example of specifying OLTP compression when creating `XMLType` tables and columns manually

Store Large Collections Out of Line

When the total number of elements and attributes defined by a `complexType` reaches 1000, it is not possible to create a single table that can manage the SQL objects that are generated when an instance of that type is stored in the database. If you have large collections, then you might run up against this limit of 1000 columns for a table.

You can use annotations `xdb:defaultTable` and `xdb:SQLInline` to specify that such collection elements be stored out of line. That means that their data is stored in a separate table—only a reference to a row in that table is stored in the main collection table. Use `xdb:defaultTable` to name the out-of -line table. Annotate each element of a potentially large collection with `xdb:SQLInline = "false"`, to store it out of line.

Note: For each inheritance hierarchy or substitution group in an XML schema, a table is created whose columns cover the content models of that hierarchy or substitution group. This too can cause the 1000-column limit to be reached.

See Also:

- "Issues with Large XML Schemas" on page 18-51
- "Setting Annotation Attribute xdb:SQLInline to false for Out-Of-Line Storage" on page 18-36

Querying a Registered XML Schema to Obtain Annotations

The registered version of an XML schema contains a full set of Oracle XML DB annotations. These annotations were supplied by a user or set by default during XML schema registration.

You can query database views `USER_XML_SCHEMAS` and `ALL_XML_SCHEMAS` to obtain a registered XML schema with all of its annotations. Example 18–6 illustrates this. It returns the XML schema as an `XMLType` instance.

Example 18–6 Querying View USER_XML_SCHEMAS for a Registered XML Schema

```
SELECT SCHEMA FROM USER_XML_SCHEMAS
  WHERE SCHEMA_URL = 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd';
```

As shown in Example 17–3 on page 17-11 and Example 17–4 on page 17-12, the location of the registered XML schema depends on whether it is local or global. If you want to project specific annotation information to relational columns, you can query

RESOURCE_VIEW. Example 18–7 illustrates this. It obtains the set of global complexType definitions declared by an XML schema for object-relational storage of XMLType data, and the corresponding SQL object types and DOM fidelity values.

Example 18–7 Querying Metadata from a Registered XML Schema

```
SELECT ct.xmlschema_type_name, ct.sql_type_name, ct.dom_fidelity
  FROM RESOURCE_VIEW,
       XMLTable(
         XMLNAMESPACES (
           'http://xmlns.oracle.com/xdb/XDBResource.xsd' AS "r",
           'http://xmlns.oracle.com/xdb/documentation/purchaseOrder' AS "po",
           'http://www.w3.org/2001/XMLSchema' AS "xs",
           'http://xmlns.oracle.com/xdb' AS "xdb"),
         '/r:Resource/r:Contents/xs:schema/xs:complexType' PASSING RES
         COLUMNS
           xmlschema_type_name VARCHAR2(30) PATH '@name',
           sql_type_name       VARCHAR2(30) PATH '@xdb:SQLType',
           dom_fidelity        VARCHAR2(6)  PATH '@xdb:maintainDOM') ct
  WHERE
    equals_path(
      RES,
      '/sys/schemas/SCOTT/xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd')
    =1;

XMLSCHEMA_TYPE_NAME         SQL_TYPE_NAME             DOM_FIDELITY
--------------------------  ------------------------  ------------
PurchaseOrderType           PURCHASEORDER_T           true
LineItemsType               LINEITEMS_T               true
LineItemType                LINEITEM_T                true
PartType                    PART_T                    true
ActionsType                 ACTIONS_T                 true
RejectionType               REJECTION_T               true
ShippingInstructionsType    SHIPPING_INSTRUCTIONS_T   true

7 rows selected.
```

Obtaining Annotations from One XML Schema to Apply to Another

Sometimes you need to apply the annotations from one XML schema to another XML schema. A typical use case is applying the annotations from an older version of an XML schema to a new version. For example, you might obtain a new version of a standard or other third-party XML schema and need to apply to it all of the annotations that you added to an older version.

You can use PL/SQL function getSchemaAnnotations to obtain all of the annotations from an XML schema, and then use PL/SQL procedure setSchemaAnnotations. These subprograms are in PL/SQL package DBMS_XMLSCHEMA_ANNOTATE.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference*, chapter "DBMS_XMLSCHEMA_ANNOTATE" for information about PL/SQL subprograms getSchemaAnnotations and setSchemaAnnotations.

How to Map XML Schema Data Types to SQL Data Types

This section describes how to use PL/SQL package DBMS_XMLSCHEMA to map data types for XML Schema attributes and elements to SQL data types.

Note: Do *not* directly access the SQL data types that are mapped from XML Schema data types during XML schema registration. These SQL types are part of the implementation of Oracle XML DB. They are not exposed for your use.

Oracle reserves the right to change the implementation at any time, including in a product patch. Such a change by Oracle will have no effect on applications that abide by the XML abstraction, but it might impact applications that directly access these data types.

Example of Mapping XML Schema Data Types to SQL

Example 18–8 shows a simple example of mapping XML Schema data types to SQL data types. It uses attribute `SQLType` to specify the data-type mapping. It also uses attribute `SQLName` to specify the object attributes to use for various XML elements and attributes.

Example 18–8 Mapping XML Schema Data Types to SQL Data Types Using Attribute SQLType

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0">
  <xs:element name="PurchaseOrder" type="PurchaseOrderType" xdb:defaultTable="PURCHASEORDER"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Reference" type="ReferenceType" minOccurs="1" xdb:SQLName="REFERENCE"/>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" minOccurs="1" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                  xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                  xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
      <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
      <xs:element name="Notes" type="po:NotesType" xdb:SQLType="CLOB"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"
                  xdb:SQLName="LINEITEM" xdb:SQLCollType="LINEITEM_V"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Description" type="DescriptionType"
                  xdb:SQLName="DESCRIPTION"/>
      <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                  xdb:SQLType="NUMBER"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T">
    <xs:attribute name="Id" xdb:SQLName="PART_NUMBER" xdb:SQLType="VARCHAR2">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:minLength value="10"/>
          <xs:maxLength value="14"/>
        </xs:restriction>
      </xs:simpleType>
```

```
    </xs:attribute>
    <xs:attribute name="Quantity" type="moneyType" xdb:SQLName="QUANTITY"/>
    <xs:attribute name="UnitPrice" type="quantityType" xdb:SQLName="UNITPRICE"/>
  </xs:complexType>

  ...

  <xs:complexType name="ActionsType" xdb:SQLType="ACTIONS_T">
    <xs:sequence>
      <xs:element name="Action" maxOccurs="4" xdb:SQLName="ACTION" xdb:SQLCollType="ACTION_V">
        <xs:complexType xdb:SQLType="ACTION_T">
          <xs:sequence>
            <xs:element name="User" type="UserType" xdb:SQLName="ACTIONED_BY"/>
            <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_ACTIONED"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
    <xs:all>
      <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
      <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
      <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
    </xs:all>
  </xs:complexType>
  <xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
    <xs:sequence>
      <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
      <xs:element name="address" type="AddressType" minOccurs="0" xdb:SQLName="SHIP_TO_ADDRESS"/>
      <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
    </xs:sequence>
  </xs:complexType>
  ...
</xs:schema>
```

XML Schema Attribute Data Types Mapped to SQL

An attribute declaration can specify its XML Schema data type in terms of one of the following:

- Primitive type
- Global `simpleType`, declared within this XML schema or in an external XML schema
- Reference to global attribute (`ref=". ."`), declared within this XML schema or in an external XML schema
- Local `simpleType`

In all cases, the SQL data type, its associated information (length, precision), and the memory mapping information are derived from the `simpleType` on which the attribute is based.

Overriding the SQLType Value in an XML Schema When Declaring Attributes

You can explicitly specify a `SQLType` value in the input XML schema document. In this case, the data type you specify is used for schema validation. This allows for the following specific forms of overrides:

- If the default SQL data type is `STRING`, you can override it with `CHAR`, `VARCHAR`, or `CLOB`.
- If the default SQL data type is `RAW`, you can override it with `RAW` or `BLOB`.

XML Schema Element Data Types Mapped to SQL

An element declaration can specify its XML Schema data type in terms of one of the following:

- Any of the ways for specifying type for an attribute declaration. See "XML Schema Attribute Data Types Mapped to SQL" on page 18-19.
- Global `complexType`, specified within this XML schema document or in an external XML schema.
- Reference to a global element (`ref="..."`), which could itself be within this XML schema document or in an external XML schema.
- Local `complexType`.

Override of the SQLType Value in an XML Schema When Declaring Elements

An element based on a `complexType` is, by default, mapped to a SQL object type that contains object attributes corresponding to each of the sub-elements and attributes. You can override this mapping by explicitly specifying a value for attribute `SQLType` in the input XML schema. The following values for `SQLType` are permitted here:

- `VARCHAR2`
- `RAW`
- `CLOB`
- `BLOB`

These represent storage of the XML data in a text form in the database.

For example, to override the `SQLType` from `VARCHAR2` to `CLOB`, declare the `xdb` namespace using `xmlns:xdb="http://xmlns.oracle.com/xdb"`, and then use `xdb:SQLType = "CLOB"`.

The following special cases are handled:

- If a cycle is detected when processing the `complexType` values that are used to declare elements and the elements declared within the `complexType`, the `SQLInline` attribute is forced to be `false`, and the correct SQL mapping is set to `REF XMLType`.
- If `maxOccurs > 1`, a varray type might be created.
  - If `SQLInline = "true"`, then a varray type is created whose element type is the SQL data type previously determined. Cardinality of the varray is based on the value of attribute `maxOccurs`. Either you specify the name of the varray type using attribute `SQLCollType`, or it is derived from the element name.
  - If `SQLInline = "false"`, then the SQL data type is set to `XDB.XDB$XMLTYPE_REF_LIST_T`. This is a predefined data type that represents an array of `REF` values pointing to `XMLType` instances.
- If the element is a global element, or if `SQLInline = "false"`, then the system creates a default table. Either you specify the name of the default table, or it is derived from the element name.

How XML Schema simpleType Is Mapped to SQL

This section describes how XML schema definitions map XML Schema `simpleType` to SQL object types. Figure 18–1 shows an example of this.

Figure 18–1 simpleType Mapping: XML Strings to SQL VARCHAR2 or CLOB

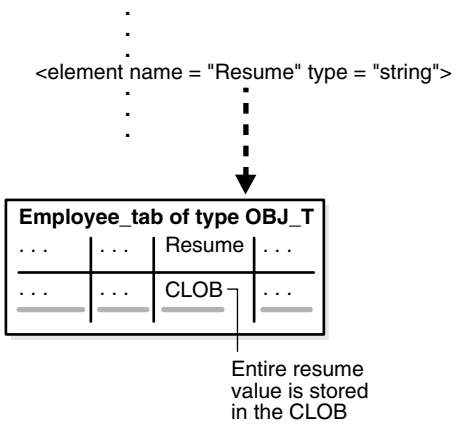


Table 18–4 through Table 18–7 present the default mapping of XML Schema `simpleType` to SQL, as specified in the XML Schema definition. For example:

- A XML Schema *primitive* type is mapped to the closest SQL data type. For example, `DECIMAL`, `POSITIVEINTEGER`, and `FLOAT` are all mapped to SQL `NUMBER`.
- An XML Schema *enumeration* type is mapped to a SQL object type with a single `RAW(`*n*`)` object attribute. The value of *n* is determined by the number of possible values in the enumeration declaration.
- An XML Schema *list* or a *union* type is mapped to a SQL string (`VARCHAR2` or `CLOB`) data type.

Table 18–4 XML Schema String Data Types Mapped to SQL

XML Schema String Type	Length or MaxLength Facet	Default SQL Data Type	Compatible SQL Data Type
`string`	n	`VARCHAR2(n)` if n < 4000, else `VARCHAR2(4000)`	`CHAR`, `CLOB`
`string`	-	`VARCHAR2(4000)` if `mapUnboundedStringToLob = "false"`, `CLOB`	`CHAR`, `CLOB`

Table 18–5 XML Schema Binary Data Types (hexBinary/base64Binary) Mapped to SQL

XML Schema Binary Type	Length or MaxLength Facet	Default SQL Data Type	Compatible SQL Data Type
`hexBinary`, `base64Binary`	n	`RAW(n)` if n < 2000, else `RAW(2000)`	`RAW`, `BLOB`
`hexBinary`, `base64Binary`	-	`RAW(2000)` if `mapUnboundedStringToLob = "false"`, `BLOB`	`RAW`, `BLOB`

Table 18–6 Default Mapping of Numeric XML Schema Primitive Types to SQL

XML Schema Simple Type	Default SQL Data Type	totalDigits (m), fractionDigits(n) Specified	Compatible SQL Data Types
float	NUMBER	NUMBER(m+n,n)	FLOAT, DOUBLE, BINARY_FLOAT
double	NUMBER	NUMBER(m+n,n)	FLOAT, DOUBLE, BINARY_DOUBLE
decimal	NUMBER	NUMBER(m+n,n)	FLOAT, DOUBLE
integer	NUMBER	NUMBER(m+n,n)	NUMBER
nonNegativeInteger	NUMBER	NUMBER(m+n,n)	NUMBER
positiveInteger	NUMBER	NUMBER(m+n,n)	NUMBER
nonPositiveInteger	NUMBER	NUMBER(m+n,n)	NUMBER
negativeInteger	NUMBER	NUMBER(m+n,n)	NUMBER
long	NUMBER(20)	NUMBER(m+n,n)	NUMBER
unsignedLong	NUMBER(20)	NUMBER(m+n,n)	NUMBER
int	NUMBER(10)	NUMBER(m+n,n)	NUMBER
unsignedInt	NUMBER(10)	NUMBER(m+n,n)	NUMBER
short	NUMBER(5)	NUMBER(m+n,n)	NUMBER
unsignedShort	NUMBER(5)	NUMBER(m+n,n)	NUMBER
byte	NUMBER(3)	NUMBER(m+n,n)	NUMBER
unsignedByte	NUMBER(3)	NUMBER(m+n,n)	NUMBER

Table 18–7 XML Schema Date and Time Data Types Mapped to SQL

XML Schema Date or Time Type	Default SQL Data Type	Compatible SQL Data Types
dateTime	TIMESTAMP	TIMESTAMP WITH TIME ZONE, DATE
time	TIMESTAMP	TIMESTAMP WITH TIME ZONE, DATE
date	DATE	TIMESTAMP WITH TIME ZONE
gDay	DATE	TIMESTAMP WITH TIME ZONE
gMonth	DATE	TIMESTAMP WITH TIME ZONE
gYear	DATE	TIMESTAMP WITH TIME ZONE
gYearMonth	DATE	TIMESTAMP WITH TIME ZONE
gMonthDay	DATE	TIMESTAMP WITH TIME ZONE
duration	VARCHAR2(4000)	none

Table 18–8 Default Mapping of Other XML Schema Primitive and Derived Data Types to SQL

XML Schema Primitive or Derived Type	Default SQL Data Type	Compatible SQL Data Types
boolean	RAW(1)	VARCHAR2
language(string)	VARCHAR2(4000)	CLOB, CHAR
NMTOKEN(string)	VARCHAR2(4000)	CLOB, CHAR
NMTOKENS(string)	VARCHAR2(4000)	CLOB, CHAR
Name(string)	VARCHAR2(4000)	CLOB, CHAR

Table 18–8 (Cont.) Default Mapping of Other XML Schema Primitive and Derived Data Types to SQL

XML Schema Primitive or Derived Type	Default SQL Data Type	Compatible SQL Data Types
NCName(string)	VARCHAR2(4000)	CLOB, CHAR
ID	VARCHAR2(4000)	CLOB, CHAR
IDREF	VARCHAR2(4000)	CLOB, CHAR
IDREFS	VARCHAR2(4000)	CLOB, CHAR
ENTITY	VARCHAR2(4000)	CLOB, CHAR
ENTITIES	VARCHAR2(4000)	CLOB, CHAR
NOTATION	VARCHAR2(4000)	CLOB, CHAR
anyURI	VARCHAR2(4000)	CLOB, CHAR
anyType	VARCHAR2(4000)	CLOB, CHAR
anySimpleType	VARCHAR2(4000)	CLOB, CHAR
QName	XDB.XDB$QNAME	none
normalizedString	VARCHAR2(4000)	none
token	VARCHAR2(4000)	none

NCHAR, NVARCHAR2, and NCLOB SQLType Values are Not Supported

Oracle XML DB does *not* support NCHAR, NVARCHAR2, and NCLOB as values for attribute SQLType: you cannot specify that an XML element or attribute is to be of type NCHAR, NVARCHAR2, or NCLOB. Also, if you provide your own data type, do not use any of these data types.

See Also: Appendix B, "Oracle XML DB Restrictions"

simpleType: Mapping XML Strings to SQL VARCHAR2 Versus CLOB

If an XML schema specifies an XML Schema data type to be a string with a maxLength less than 4000, then it is mapped to a VARCHAR2 object attribute of the specified length. However, if maxLength is not specified in the XML schema, then it can only be mapped to a LOB. This is sub-optimal when most of the string values are small and only a small fraction of them are large enough to need a LOB.

See Also: Table 18–4, " XML Schema String Data Types Mapped to SQL" on page 18-21

Working with Time Zones

The following XML Schema data types allow for an optional time-zone indicator as part of their literal values.

- xsd:dateTime
- xsd:time
- xsd:date
- xsd:gYear
- xsd:gMonth
- xsd:gDay
- xsd:gYearMonth

- xsd:gMonthDay

By default, XML schema registration maps xsd:dateTime and xsd:time to SQL data type TIMESTAMP and all the other data types to SQL data type DATE. SQL data types TIMESTAMP and DATE do not permit a time-zone indicator.

If your application needs to work with time-zone indicators, then use attribute SQLType to specify the SQL data type as TIMESTAMP WITH TIME ZONE. This ensures that values containing time-zone indicators can be stored and retrieved correctly. For example:

```
<element name="dob" type="xsd:dateTime"
         xdb:SQLType="TIMESTAMP WITH TIME ZONE"/>
<attribute name="endofquarter" type="xsd:gMonthDay"
          xdb:SQLType="TIMESTAMP WITH TIME ZONE"/>
```

Using Trailing Z to Indicate UTC Time Zone XML Schema lets the time-zone component be specified as Z, to indicate UTC time zone. When a value with a trailing Z is stored in a SQL TIMESTAMP WITH TIME ZONE column, the time zone is actually stored as +00:00. Thus, the retrieved value contains the trailing +00:00, not the original Z. For example, if the value in the input XML document is 1973-02-12T13:44:32**Z**, the output is 1973-02-12T13:44:32**.000000+00:00**.

How XML Schema complexType Is Mapped to SQL

Using XML Schema, a complexType is mapped to a SQL object type as follows:

- XML attributes declared within the complexType are mapped to SQL object attributes. The simpleType defining an XML attribute determines the SQL data type of the corresponding object attribute.
- XML elements declared within the complexType are also mapped to SQL object attributes. The simpleType or complexType defining an XML element determines the SQL data type of the corresponding object attribute.

If the XML element is declared with attribute maxOccurs > 1 then it is mapped to a SQL collection (object) attribute. The collection could be a varray value (the default, recommended) or an unordered table (if you set deprecated attribute xdb:maintainOrder[3] to false). The default storage of a varray value is an ordered collections table (OCT). You can choose LOB storage instead, by setting deprecated attribute xdb:storeVarrayAsTable[3] to false.

Attribute Specification in a complexType XML Schema Declaration

When an element is based on a global complexType, attribute SQLType must be specified for the complexType declaration. You can optionally include the same SQLType attribute within the element declaration.

If you do not specify attribute SQLType for the global complexType, Oracle XML DB creates a SQLType attribute with an internally generated name. The elements that reference this global type *cannot* then have a different value for SQLType. The following code is acceptable:

```
<xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
  <xs:sequence>
    <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"
                xdb:SQLName="LINEITEM" xdb:SQLCollType="LINEITEM_V"/>
```

[3] XML Schema annotations xdb:maintainOrder and xdb:storeVarrayAsTable are *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1).

```
  </xs:sequence>
</xs:complexType>
<xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
  <xs:sequence>
    <xs:element name="Description" type="DescriptionType"
                xdb:SQLName="DESCRIPTION"/>
    <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
  </xs:sequence>
  <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                xdb:SQLType="NUMBER"/>
</xs:complexType>
<xs:complexType name="PartType" xdb:SQLType="PART_T">
  <xs:attribute name="Id" xdb:SQLName="PART_NUMBER" xdb:SQLType="VARCHAR2">
    <xs:simpleType>
      <xs:restriction base="xs:string">
        <xs:minLength value="10"/>
        <xs:maxLength value="14"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="Quantity" type="moneyType" xdb:SQLName="QUANTITY"/>
  <xs:attribute name="UnitPrice" type="quantityType" xdb:SQLName="UNITPRICE"/>
</xs:complexType>
```

complexType Extensions and Restrictions in Oracle XML DB

In XML Schema, `complexType` values are declared based on `complexContent` and `simpleContent`.

- `simpleContent` is declared as an extension of `simpleType`.
- `complexContent` is declared as one of the following:
  - Base type
  - `complexType` extension
  - `complexType` restriction

This section describes the Oracle XML DB extensions and restrictions to `complexType`.

complexType Declarations in XML Schema: Handling Inheritance

For `complexType`, Oracle XML DB handles inheritance in the XML schema as follows:

- For complex types declared to *extend* other complex types, the SQL type corresponding to the base type is specified as the supertype for the current SQL type. Only the additional attributes and elements declared in the sub-complextype are added as attributes to the sub-object-type.
- For complex types declared to *restrict* other complex types, the SQL type for the sub-complex type is set to be the same as the SQL type for its base type. This is because SQL does not support restriction of object types through the inheritance mechanism. Any constraints are imposed by the restriction in XML schema.

Example 18–9 shows the registration of an XML schema that defines a base `complexType Address` and two extensions `USAddress` and `IntlAddress`.

Example 18–9 XML Schema Inheritance: complexContent as an Extension of complexTypes

```
DECLARE
```

```
  doc VARCHAR2(3000) :=
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:complexType name="Address" xdb:SQLType="ADDR_T">
         <xs:sequence>
           <xs:element name="street" type="xs:string"/>
           <xs:element name="city" type="xs:string"/>
         </xs:sequence>
       </xs:complexType>
       <xs:complexType name="USAddress" xdb:SQLType="USADDR_T">
         <xs:complexContent>
           <xs:extension base="Address">
             <xs:sequence>
               <xs:element name="zip" type="xs:string"/>
             </xs:sequence>
           </xs:extension>
         </xs:complexContent>
       </xs:complexType>
       <xs:complexType name="IntlAddress" final="#all" xdb:SQLType="INTLADDR_T">
         <xs:complexContent>
           <xs:extension base="Address">
             <xs:sequence>
               <xs:element name="country" type="xs:string"/>
             </xs:sequence>
           </xs:extension>
         </xs:complexContent>
       </xs:complexType>
     </xs:schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/PO.xsd',
    SCHAMEDOC => doc);
END;
```

Note: Type `intladdr_t` is created as a *final* type because the corresponding `complexType` specifies the "`final`" attribute. By default, all `complexTypes` can be extended and restricted by other types, so all SQL object types are created as types that are *not* final.

```
CREATE TYPE addr_t AS OBJECT(SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                             "street" VARCHAR2(4000),
                             "city" VARCHAR2(4000)) NOT FINAL;
CREATE TYPE usaddr_t UNDER addr_t ("zip" VARCHAR2(4000)) NOT FINAL;
CREATE TYPE intladdr_t UNDER addr_t ("country" VARCHAR2(4000)) FINAL;
```

Example 18–10 shows the registration of an XML schema that defines a base `complexType Address` and a restricted type `LocalAddress` that prohibits the specification of `country` attribute.

Example 18–10 Inheritance in XML Schema: Restrictions in complexTypes

```
DECLARE
  doc varchar2(3000) :=
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:complexType name="Address" xdb:SQLType="ADDR_T">
         <xs:sequence>
           <xs:element name="street" type="xs:string"/>
```

```
            <xs:element name="city" type="xs:string"/>
            <xs:element name="zip" type="xs:string"/>
            <xs:element name="country" type="xs:string" minOccurs="0"
                        maxOccurs="1"/>
          </xs:sequence>
        </xs:complexType>
        <xs:complexType name="LocalAddress" xdb:SQLType="USADDR_T">
          <xs:complexContent>
            <xs:restriction base="Address">
              <xs:sequence>
                <xs:element name="street" type="xs:string"/>
                <xs:element name="city" type="xs:string"/>
                <xs:element name="zip" type="xs:string"/>
                <xs:element name="country" type="xs:string"
                            minOccurs="0" maxOccurs="0"/>
              </xs:sequence>
            </xs:restriction>
          </xs:complexContent>
        </xs:complexType>
      </xs:schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/PO.xsd',
    SCHEMADOC => doc);
END;
```

Because SQL inheritance does not support a notion of restriction, the SQL data type corresponding to a restricted `complexType` is a empty subtype of the parent object type. For the XML schema of Example 18–10, Oracle XML DB generates the following SQL types:

```
CREATE TYPE addr_t AS OBJECT (SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                              "street"   VARCHAR2(4000),
                              "city"     VARCHAR2(4000),
                              "zip"      VARCHAR2(4000),
                              "country"  VARCHAR2(4000)) NOT FINAL;
CREATE TYPE usaddr_t UNDER addr_t;
```

How a complexType Based on simpleContent Is Mapped to an Object Type

A complex type based on a `simpleContent` declaration is mapped to an object type with attributes corresponding to the XML attributes and an extra `SYS_XDBBODY$` attribute corresponding to the body value. The data type of the body attribute is based on `simpleType` which defines the body type.

Example 18–11 XML Schema complexType: Mapping complexType to simpleContent

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp.xsd"
             xmlns:emp="http://www.oracle.com/emp.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="name" xdb:SQLType="OBJ_T">
         <simpleContent>
           <restriction base="string">
           </restriction>
         </simpleContent>
       </complexType>
     </schema>';
```

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/emp.xsd',
    SCHEMADOC => doc);
END;
```

For the XML schema of Example 18–11, Oracle XML DB generates the following type:

```
CREATE TYPE obj_t AS OBJECT(SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                            SYS_XDBBODY$ VARCHAR2(4000));
```

How any and anyAttribute Declarations Are Mapped to Object Type Attributes

Oracle XML DB maps the element declaration, `any`, and the attribute declaration, `anyAttribute`, to `VARCHAR2` attributes (or optionally to Large Objects (LOBs)) in the created object type. The object attribute stores the text of the XML fragment that matches the `any` declaration.

- The `namespace` attribute can be used to restrict the contents so that they belong to a specified namespace.
- The `processContents` attribute within the `any` element declaration, indicates the level of validation required for the contents matching the `any` declaration.

The code in Example 18–12 declares an `any` element and maps it to the column `SYS_XDBANY$`, in object type `obj_t`. It also declares that attribute `processContents` does not validate contents that match the `any` declaration.

Example 18–12 XML Schema: Mapping complexType to any/anyAttribute

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/any.xsd"
             xmlns:emp="http://www.oracle.com/any.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="Employee" xdb:SQLType="OBJ_T">
         <sequence>
           <element name="Name" type="string"/>
           <element name="Age" type="decimal"/>
           <any namespace="http://www/w3.org/2001/xhtml"
                processContents="skip"/>
         </sequence>
       </complexType>
     </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/emp.xsd',
    SCHEMADOC => doc);
END;
```

For the XML schema of Example 18–12, Oracle XML DB generates the following type:

```
CREATE TYPE obj_t AS OBJECT(SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                            Name VARCHAR2(4000),
                            Age NUMBER,
                            SYS_XDBANY$ VARCHAR2(4000));
```

Creating XML Schema-Based XMLType Columns and Tables

After an XML schema has been registered with Oracle XML DB, it can be referenced when defining tables that contain `XMLType` columns or creating `XMLType` tables.

If you specify no storage model when creating an `XMLType` table or column for XML schema-based data then the storage model used is that specified during registration of the referenced XML schema. If no storage model was specified for the XML schema registration, then *object-relational* storage is used.

Example 18–13 shows how to manually create table `purchaseorder`, the default table for `PurchaseOrder` elements.

Example 18–13 Creating an XMLType Table that Conforms to an XML Schema

```
CREATE TABLE purchaseorder OF XMLType
  XMLSCHEMA "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder"
  VARRAY "XMLDATA"."ACTIONS"."ACTION"
    STORE AS TABLE action_table
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
  VARRAY "XMLDATA"."LINEITEMS"."LINEITEM"
    STORE AS TABLE lineitem_table
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)));
```

The `CREATE TABLE` statement of Example 18–13 is equivalent to the `CREATE TABLE` statement that is generated automatically by Oracle XML DB when you set parameter `GENTABLES` to `TRUE` during XML schema registration.

The XML schema referenced Example 18–13 specifies that table `purchaseorder` is the default table for `PurchaseOrder` elements. When an XML document compliant with the XML schema is inserted into Oracle XML DB Repository using protocols or PL/SQL, the content of the document is stored as a row in table `purchaseorder`.

When an XML schema is registered as a *global* schema, you must grant the appropriate access rights on the default table to all other users of the database, before they can work with instance documents that conform to the globally registered XML schema.

See Also: "Local and Global XML Schemas" on page 17-11

Each member of the varray that manages the collection of `Action` elements is stored in the ordered collection table `action_table`. Each member of the varray that manages the collection of `LineItem` elements is stored as a row in ordered collection table `lineitem_table`. The ordered collection tables are heap-based. Because of the `PRIMARY KEY` specification, they automatically contain pseudocolumn `NESTED_TABLE_ID` and column `SYS_NC_ARRAY_INDEX$`, which are required to link them back to the parent column.

By default, the value of (deprecated) XML schema annotation `xdb:storeVarrayAsTable`[4] is `true`, which automatically generates ordered collection tables (OCTs) for collections during XML schema registration. These OCTs are given system-generated names, which can be difficult to work with. You can give them more meaningful names using the SQL statement `RENAME TABLE`.

The `CREATE TABLE` statement in Example 18–13 corresponds to a purchase-order document with a single level of nesting: The varray that manages the collection of `LineItem` elements is ordered collection table `lineitem_table`.

[4] XML Schema annotation `xdb:storeVarrayAsTable` is *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1).

What if you had a different XML schema that had, say, a collection of `Shipment` elements inside a `Shipments` element that was, in turn, inside a `LineItem` element? In that case, you could create the table manually as shown in Example 18–14.

Example 18–14 Creating an XMLType Table for Nested Collections

```
CREATE TABLE purchaseorder OF XMLType
  XMLSCHEMA "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder"
  VARRAY "XMLDATA"."ACTIONS"."ACTION"
    STORE AS TABLE action_table
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
                  VARRAY "XMLDATA"."LINEITEMS"."LINEITEM"
    STORE AS TABLE lineitem_table
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$))
                   VARRAY "SHIPMENTS"."SHIPMENT"
                     STORE AS TABLE shipments_table
                                   ((PRIMARY KEY (NESTED_TABLE_ID,
                                                  SYS_NC_ARRAY_INDEX$))));
```

A SQL*Plus `DESCRIBE` statement can be used to view information about an `XMLType` table, as shown in Example 18–15.

Example 18–15 Using DESCRIBE with an XML Schema-Based XMLType Table

```
DESCRIBE purchaseorder
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
TABLE of SYS.XMLTYPE(XMLSchema
"http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd"
Element "PurchaseOrder") STORAGE Object-relational TYPE "PURCHASEORDER_T"
```

The output of the `DESCRIBE` statement of Example 18–15 shows the following information about table `purchaseorder`:

- The table is an `XMLType` table
- The table is constrained to storing `PurchaseOrder` documents as defined by the `PurchaseOrder` XML schema
- Rows in this table are stored as a set of objects in the database
- SQL type `purchaseorder_t` is the base object for this table

Partitioning of XMLType Tables and Columns Stored Object-Relationally

This section is about `XMLType` data that is stored object-relationally.

When you partition an `XMLType` table or a table with an `XMLType` column using list, range, or hash partitioning, any ordered collection tables (OCTs) or out-of-line tables within the data are automatically partitioned accordingly, by default.

This **equipartitioning** means that the partitioning of an OCT or an out-of-line table follows the partitioning scheme of its parent (base) table. There is a corresponding child-table partition for each partition of the base table. A child element is stored in the child-table partition that corresponds to the base-table partition of its parent element.

Storage attributes for a base table partition are, by default, also used for the corresponding child-table partitions. You can override these storage attributes for a given child-table partition.

Similarly, by default, the name of an OCT partition is the same as its base (parent) table, but you can override this behavior by specifying the name to use. The name of an out-of-line table partition is always the same as the partition of its parent-table (which could be a base table or an OCT).

Note:

- Equipartitioning of `XMLType` data stored object-relationally is not available in releases prior to Oracle Database 11*g* Release 1 (11.1).
- Equipartitioning of `XMLType` data that is stored out of line is not available in releases prior to Oracle Database 11*g* Release 2 (11.2.0.2). Starting with that release, out-of-line tables are not shared: You cannot create two top-level tables that are based on the same XML schema, if that schema specifies an out-of-line table.

You can prevent partitioning of OCTs by specifying the keyword `GLOBAL` in a `CREATE TABLE` statement. (Starting with Oracle Database 11g Release 1 (11.1), the default behavior uses keyword `LOCAL`). For information about converting a non-partitioned collection table to a partitioned collection table, see *Oracle Database VLDB and Partitioning Guide*.

You can prevent partitioning of out-of-line tables, and thus allow out-of-line sharing, by turning on event 31178 with level 0x200:

```
ALTER SESSION SET EVENTS '31178 TRACE NAME CONTEXT FOREVER, LEVEL
0x200'
```

See Also: *Oracle Database SQL Language Reference* for information about creating tables with partitions using keywords `GLOBAL` and `LOCAL`

Examples of Partitioning XMLType Data

You can specify partitioning information for an `XMLType` base table in two ways:

- During XML schema registration, using XML Schema annotation `xdb:tableProps`
- During table creation using `CREATE TABLE`

Example 18–16 and Example 18–17 illustrate this. These two examples have exactly the same effect. They partition the base `purchaseorder` table using the `Reference` element to specify ranges. They equipartition the child table of line items with respect to the base table.

Example 18–16 shows element `PurchaseOrder` from the purchase-order XML schema, annotated to partition the base table and its child table of line items.

Example 18–16 Specifying Partitioning Information During XML Schema Registration

```
<xs:element name="PurchaseOrder" type="PurchaseOrderType"
            xdb:defaultTable="PURCHASEORDER"
            xdb:tableProps =
              "VARRAY XMLDATA.LINEITEMS.LINEITEM
                 STORE AS TABLE lineitem_table
                   ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
                  PARTITION BY RANGE (XMLDATA.Reference)
```

```
(PARTITION p1 VALUES LESS THAN (1000)
   VARRAY XMLDATA.LINEITEMS.LINEITEM
     STORE AS TABLE lineitem_p1 (STORAGE (MINEXTENTS 13)),
 PARTITION p2 VALUES LESS THAN (2000)
   VARRAY XMLDATA.LINEITEMS.LINEITEM
     STORE AS TABLE lineitem_p2 (STORAGE (MINEXTENTS 13)))"/>
```

Example 18–17 specifies the same partitioning as in Example 18–16, but it does so during the creation of the base table `purchaseorder`.

Example 18–17 Specifying Partitioning Information During Table Creation

```
CREATE TABLE purchaseorder OF XMLType
  XMLSCHEMA "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder"
  VARRAY "XMLDATA"."LINEITEMS"."LINEITEM" STORE AS TABLE lineitem_table
    ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
    PARTITION BY RANGE (XMLDATA.Reference)
      (PARTITION p1 VALUES LESS THAN (1000)
         VARRAY "XMLDATA"."LINEITEMS"."LINEITEM" STORE AS TABLE lineitem_p1
           (STORAGE (MINEXTENTS 13)),
       PARTITION p2 VALUES LESS THAN (2000)
         VARRAY  "XMLDATA"."LINEITEMS"."LINEITEM" STORE AS TABLE lineitem_p2
           (STORAGE (MINEXTENTS 13)));
```

Example 18–16 and Example 18–17 also show how you can specify object storage options for the individual child-table partitions. In this case, the `STORAGE` clauses specify that extents of size 14M are to be allocated initially for each of the child-table partitions.

See Also:

- "Annotated Purchase-Order XML Schema" on page A-34
- *Oracle Database Object-Relational Developer's Guide* for more information about partitioning object-relational data
- *Oracle Database VLDB and Partitioning Guide* for more information about partitioning

Partition Maintenance

You need not define or maintain child-table partitions manually. When you perform partition maintenance on the base (parent) table, corresponding maintenance is automatically performed on the child tables as well.

There are a few exceptions to the general rule that you perform partition maintenance only on the base table. In the following cases you perform maintenance on a child table:

- Modify the *default* physical storage attributes of a collection partition
- Modify the physical storage attributes of a collection partition
- Move a collection partition to a different segment, possibly in a different tablespace
- Rename a collection partition

For example, if you change the tablespace of a base table, that change is not cascaded to its child-table partitions. You must manually use `ALTER TABLE MOVE PARTITION` on the child-table partitions to change their tablespace.

Other than those exceptional operations, you perform all partition maintenance on the base table only. This includes operations such as adding, dropping, and splitting a partition.

Online partition redefinition is also supported for child tables. You can copy unpartitioned child tables to partitioned child tables during online redefinition of a base table. You typically specify parameter values `copy_indexes => 0` and `copy_constraints => false` for PL/SQL procedure `DBMS_REDEFINITION.copy_table_dependents`, to protect the indexes and constraints of the newly defined child tables.

See Also:

- *Oracle Database SQL Language Reference* for information about SQL statement `ALTER TABLE`
- *Oracle Database PL/SQL Packages and Types Reference* for information about online partition redefinition using PL/SQL package `DBMS_REDEFINITION`

Specifying Relational Constraints on XMLType Tables and Columns

When you store `XMLType` data using object-relational storage, typical relational constraints can be specified for elements and attributes that occur only once in an XML document.

Example 18–18 defines uniqueness and foreign-key constraints on `XMLType` table `purchaseorder` in standard database schema `OE`.

For `XMLType` data that is stored object-relationally, such as that in table `OE.purchaseorder`, constraints must be specified in terms of object attributes of the SQL data types that are used to manage the XML content.

Example 18–18 Integrity Constraints and Triggers for an XMLType Table Stored Object-Relationally

```
ALTER TABLE purchaseorder
  ADD CONSTRAINT reference_is_unique
  UNIQUE (XMLDATA."REFERENCE");

ALTER TABLE purchaseorder
  ADD CONSTRAINT user_is_valid
  FOREIGN KEY (XMLDATA."USERID") REFERENCES hr.employees(email);

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'purchaseOrder.xml'),
                  nls_charset_id('AL32UTF8')));

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'DuplicateReference.xml'),
                  nls_charset_id('AL32UTF8')));

INSERT INTO purchaseorder
*
ERROR at line 1:
ORA-00001: unique constraint (QUINE.REFERENCE_IS_UNIQUE) violated

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'InvalidUser.xml'),
                  nls_charset_id('AL32UTF8')));
```

```
INSERT INTO purchaseorder
*
ERROR at line 1:
ORA-02291: integrity constraint (QUINE.USER_IS_VALID) violated - parent key not
 found
```

Example 18–18 is similar to Example 3–8 on page 3-6, which defines a uniqueness constraint on a binary XML table. But in addition, Example 18–18 defines a foreign-key constraint that requires element `User` of each `OE.purchaseorder` document to be the e-mail address of an employee that is in table `employees` of standard database schema `HR`.

Just as for Example 3–8, the uniqueness constraint `reference_is_unique` of Example 18–18 ensures the uniqueness of element `Reference` across all documents stored in the table. The foreign key constraint `user_is_valid` ensures that the value of element `User` corresponds to a value in column `email` of table `HR.employees`.

The text node associated with element `Reference` in the XML document `DuplicateReference.xml` contains the same value as the corresponding node in XML document `PurchaseOrder.xml`. Attempting to store both documents in Oracle XML DB thus violates the constraint `reference_is_unique`.

The text node associated with element `User` in XML document `InvalidUser.xml` contains the value `HACKER`. There is no entry in table `HR.employees` where the value of column `email` is `HACKER`. Attempting to store this document in Oracle XML DB violates the foreign-key constraint `user_is_valid`.

See Also:

- "Enforcing Referential Integrity Using SQL Constraints" on page 3-5, and Example 3–8 on page 3-6 in particular
- "Enforcing XML Data Integrity Using the Database" on page 3-4 for information about defining contraints for `XMLType` data stored as binary XML
- "Adding Unique Constraints to the Parent Element of an Attribute" on page 18-34

Adding Unique Constraints to the Parent Element of an Attribute

After creating an `XMLType` table based on an XML schema, how can you add a unique constraint to the parent element of an attribute? You might, for example, want to create a unique key based on an attribute of an element that repeats itself (a collection).

To create constraints on elements that can occur more than once, store the varray as an ordered collection table (OCT). You can then create constraints on the OCT.

Example 18–19 shows an XML schema that lets attribute `No` of element `<PhoneNumber>` appear more than once. The example shows how you can add a unique constraint to ensure that the same phone number cannot be repeated within a given instance document.

Example 18–19 Adding a Unique Constraint to the Parent Element of an Attribute

```
BEGIN DBMS_XMLSCHEMA.registerSchema(
  SCHEMAURL => 'emp.xsd',
  SCHEMADOC => '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                           xmlns:xdb="http://xmlns.oracle.com/xdb">
                 <xs:element name="Employee" xdb:SQLType="EMP_TYPE">
                   <xs:complexType>
```

```
                    <xs:sequence>
                      <xs:element name="EmployeeId" type="xs:positiveInteger"/>
                      <xs:element name="PhoneNumber" maxOccurs="10"/>
                        <xs:complexType>
                          <xs:attribute name="No" type="xs:integer"/>
                        </xs:complexType>
                      </xs:element>
                    </xs:sequence>
                  </xs:complexType>
                </xs:element>
              </xs:schema>',
   LOCAL     => FALSE,
   GENTYPES  => FALSE);
END;
/

PL/SQL procedure successfully completed.

CREATE TABLE emp_tab OF XMLType
  XMLSCHEMA "emp.xsd" ELEMENT "Employee"
  VARRAY XMLDATA."PhoneNumber" STORE AS TABLE phone_tab;

Table created.

ALTER TABLE phone_tab ADD UNIQUE (NESTED_TABLE_ID, "No");

Table altered.

INSERT INTO emp_tab
  VALUES(XMLType('<Employee>
                    <EmployeeId>1234</EmployeeId>
                    <PhoneNumber No="1234"/>
                    <PhoneNumber No="2345"/>
                  </Employee>').createSchemaBasedXML('emp.xsd'));

1 row created.

INSERT INTO emp_tab
  VALUES(XMLType('<Employee>
                    <EmployeeId>3456</EmployeeId>
                    <PhoneNumber No="4444"/>
                    <PhoneNumber No="4444"/>
                  </Employee>').createSchemaBasedXML('emp.xsd'));
```

This returns the expected result:

```
*
ERROR at line 1:
ORA-00001: unique constraint (SCOTT.SYS_C002136) violated
```

The constraint in this example applies to each collection, and not across all instances. This is achieved by creating a concatenated index with the collection id column. To apply the constraint across all collections of all instance documents, omit the collection id column.

> **Note:** You can create only a *functional* constraint as a unique or foreign key constraint on `XMLType` data stored as binary XML.

Out-Of-Line Storage of XMLType Data

By default, when XMLType data is stored object-relationally a child XML element is mapped to an embedded SQL object attribute. Sometimes better performance can be obtained by storing some XMLType data out of line. That is the topic of this section.

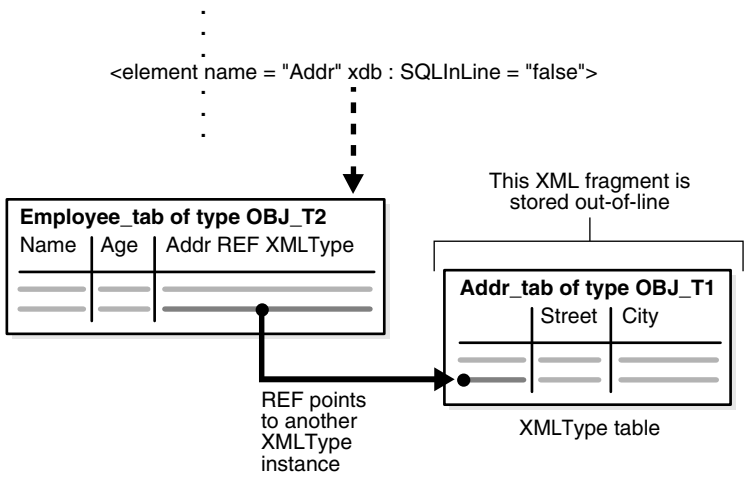
You can use XML schema annotation (attribute) xdb:SQLInline to specify that given elements are to be stored out of line.

Setting Annotation Attribute xdb:SQLInline to false for Out-Of-Line Storage

By default, a child XML element is mapped to an embedded SQL object attribute, when XMLType data is stored object-relationally. However, there are scenarios where out-of-line storage offers better performance. In such cases, set XML schema annotation (attribute) xdb:SQLInline to false, so Oracle XML DB generates a SQL object type with an embedded REF attribute. The REF points to another XMLType instance that is stored out of line and that corresponds to the XML fragment. Default XMLType tables are also created, to store the out-of-line fragments.

Figure 18–2 illustrates the mapping of complexType to SQL for out-of-line storage.

Figure 18–2 Mapping complexType to SQL for Out-Of-Line Storage



Note: Starting with Oracle Database 11g Release 2 (11.2.0.2), you can create only *one* XMLType table that uses an XML schema that results in an out-of-line table. An error is raised if you try to create a second table that uses the same XML schema.

Example 18–20 Setting SQLInline to False for Out-Of-Line Storage

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp.xsd"
             xmlns:emp="http://www.oracle.com/emp.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="EmpType" xdb:SQLType="EMP_T">
         <sequence>
           <element name="Name" type="string"/>
           <element name="Age" type="decimal"/>
```

```
          <element name="Addr"
                   xdb:SQLInline="false"
                   xdb:defaultTable="ADDR_TAB">
            <complexType xdb:SQLType="ADDR_T">
              <sequence>
                <element name="Street" type="string"/>
                <element name="City" type="string"/>
              </sequence>
            </complexType>
          </element>
        </sequence>
      </complexType>
      <element name="Employee" type="emp:EmpType"
               xdb:defaultTable="EMP_TAB"/>
    </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL        => 'emp.xsd',
    SCHEMADOC        => doc,
    ENABLE_HIERARCHY => DBMS_XMLSCHEMA.ENABLE_HIERARCHY_NONE);
END;
/
```

In Example 18–20, attribute `xdb:SQLInline` of element `Addr` has value `false`. The resulting SQL object type, `obj_t2`, has an `XMLType` column with an embedded `REF` object attribute. The `REF` attribute points to an `XMLType` instance of SQL object type `obj_t1` in table `addr_tab`. Table `addr_tab` is stored out of line. It has columns `street` and `city`.

When registering this XML schema, Oracle XML DB generates the `XMLType` tables and types shown in Example 18–21.

Example 18–21 Generated XMLType Tables and Types

```
DESCRIBE emp_tab
 Name                          Null?    Type
 ----------------------------- --------
-------------------------------------------------------------
TABLE of SYS.XMLTYPE(XMLSchema "emp.xsd" Element "Employee") STORAGE
Object-relational TYPE "EMP_T"

DESCRIBE addr_tab
 Name                          Null?    Type
 ----------------------------- --------
-------------------------------------------------------------
TABLE of SYS.XMLTYPE(XMLSchema "emp.xsd" Element "Addr") STORAGE Object-relational
TYPE "ADDR_T"

DESCRIBE emp_t
 emp_t is NOT FINAL
 Name                          Null?    Type
 ----------------------------- -------- --------------------
 SYS_XDBPD$                             XDB.XDB$RAW_LIST_T
 Name                                   VARCHAR2(4000 CHAR)
 Age                                    NUMBER
 Addr                                   REF OF XMLTYPE

DESCRIBE addr_t
 Name                          Null?    Type
 ----------------------------- -------- --------------------
```

```
 SYS_XDBPD$                              XDB.XDB$RAW_LIST_T
 Street                                  VARCHAR2(4000 CHAR)
 City                                    VARCHAR2(4000 CHAR)
```

Table emp_tab holds all of the employee information, and it contains an object reference that points to the address information that is stored out of line, in table addr_tab.

An advantage of this model is that it lets you query the out-of-line table (addr_tab) directly, to look up address information. Example 18–22 illustrates querying table addr_tab directly to obtain the distinct city information for all employees.

Example 18–22 Querying an Out-Of-Line Table

```
INSERT INTO emp_tab
  VALUES
    (XMLType('<x:Employee
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xmlns:x="http://www.oracle.com/emp.xsd"
                 xsi:schemaLocation="http://www.oracle.com/emp.xsd emp.xsd">
                <Name>Abe Bee</Name>
                <Age>22</Age>
                <Addr>
                  <Street>A Street</Street>
                  <City>San Francisco</City>
                </Addr>
              </x:Employee>'));

INSERT INTO emp_tab
  VALUES
    (XMLType('<x:Employee
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xmlns:x="http://www.oracle.com/emp.xsd"
                 xsi:schemaLocation="http://www.oracle.com/emp.xsd emp.xsd">
                <Name>Cecilia Dee</Name>
                <Age>23</Age>
                <Addr>
                  <Street>C Street</Street>
                  <City>Redwood City</City>
                </Addr>
              </x:Employee>'));
. . .

SELECT DISTINCT XMLCast(XMLQuery('/Addr/City' PASSING OBJECT_VALUE AS "."
                                                RETURNING CONTENT)
                        AS VARCHAR2(20))
  FROM addr_tab;

CITY
-------------
Redwood City
San Francisco
```

The disadvantage of this storage model is that, in order to obtain the entire Employee element, you must access an additional table for the address.

Storing Collections in Out-Of-Line Tables

You can also map collection items to be stored out of line. In this case, instead of a single REF column, the parent element contains a varray of REF values that point to the

collection members. For example, suppose that there is a list of addresses for each employee and that list is mapped to out-of-line storage, as shown in Example 18–23.

Example 18–23 Storing a Collection Out of Line

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp.xsd"
             xmlns:emp="http://www.oracle.com/emp.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="EmpType" xdb:SQLType="EMP_T">
         <sequence>
           <element name="Name" type="string"/>
           <element name="Age" type="decimal"/>
           <element name="Addr" xdb:SQLInline="false"
                    maxOccurs="unbounded" xdb:defaultTable="ADDR_TAB">
             <complexType xdb:SQLType="ADDR_T">
               <sequence>
                 <element name="Street" type="string"/>
                 <element name="City" type="string"/>
               </sequence>
             </complexType>
           </element>
         </sequence>
       </complexType>
       <element name="Employee" type="emp:EmpType"
                xdb:defaultTable="EMP_TAB"/>
     </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL        => 'emp.xsd',
    SCHEMADOC        => doc,
    ENABLE_HIERARCHY => DBMS_XMLSCHEMA.ENABLE_HIERARCHY_NONE);
END;
/
```

During registration of this XML schema, Oracle XML DB generates tables `emp_tab` and `addr_tab` and types `emp_t` and `addr_t`, just as in Example 18–20. However, this time, type `emp_t` contains a varray of `REF` values that point to addresses, instead of a single `REF` attribute, as shown in Example 18–24.

Example 18–24 Generated Out-Of-Line Collection Type

```
DESCRIBE emp_t
 emp_t is NOT FINAL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 SYS_XDBPD$                                         XDB.XDB$RAW_LIST_T
 Name                                               VARCHAR2(4000 CHAR)
 Age                                                NUMBER
 Addr                                               XDB.XDB$XMLTYPE_REF_LIST_T
```

By default, (deprecated) XML schema attribute `xdb:storeVarrayAsTable`[5] has value `true`, which means that the varray of `REF` values is stored out of line, in an intermediate table.

[5] XML Schema annotation `xdb:storeVarrayAsTable` is *deprecated*, starting with Oracle Database 12*c* Release 1 (12.1.0.1).

That is, in addition to creating the tables and types just mentioned, XML schema registration also creates the intermediate table that stores the list of REF values. This table has a system-generated name, but you can rename it. That can be useful, for example, in order to create an index on it.

Example 18–25 Renaming an Intermediate Table of REF Values

```
DECLARE
  gen_name VARCHAR2 (4000);
BEGIN
  SELECT TABLE_NAME INTO gen_name FROM USER_NESTED_TABLES
    WHERE PARENT_TABLE_NAME = 'EMP_TAB';
  EXECUTE IMMEDIATE 'RENAME "' || gen_name || '"TO emp_tab_reflist';
END;
/

DESCRIBE emp_tab_reflist
 Name                    Null?    Type
 ----------------------- -------- ----------------
 COLUMN_VALUE                     REF OF XMLTYPE
```

Example 18–26 shows a query that selects the names of all San Francisco-based employees and the streets in which they live. The example queries the address table on element City, and joins back with the employee table. The explain-plan fragment shown indicates a join between tables emp_tab_reflist and emp_tab.

Example 18–26 XPath Rewrite for an Out-Of-Line Collection

```
SELECT em.name, ad.street
  FROM emp_tab,
       XMLTable(XMLNAMESPACES ('http://www.oracle.com/emp.xsd' AS "x"),
                '/x:Employee' PASSING OBJECT_VALUE
                COLUMNS name   VARCHAR2(20) PATH 'Name') em,
       XMLTable(XMLNAMESPACES ('http://www.oracle.com/emp.xsd' AS "x"),
                '/x:Employee/Addr' PASSING OBJECT_VALUE
                COLUMNS street VARCHAR2(20) PATH 'Street',
                        city   VARCHAR2(20) PATH 'City') ad
  WHERE ad.city = 'San Francisco';

NAME                 STREET
-------------------- --------------------
Abe Bee              A Street
Eve Fong             E Street
George Hu            G Street
Iris Jones           I Street
Karl Luomo           K Street
Marina Namur         M Street
Omar Pinano          O Street
Quincy Roberts       Q Street

8 rows selected.
```

```
|   4 |    TABLE ACCESS FULL         | EMP_TAB_REFLIST |    32 |   640 |     2   (0)| 00:00:01 |
|   5 |   TABLE ACCESS BY INDEX ROWID| EMP_TAB         |     1 |    29 |     1   (0)| 00:00:01 |
|*  6 |    INDEX UNIQUE SCAN         | SYS_C005567     |     1 |       |     0   (0)| 00:00:01 |
```

To improve performance you can create an index on the REF values in the intermediate table, emp_tab_reflist. This lets Oracle XML DB query the address table, obtain an object reference (REF) to the relevant row, join it with the intermediate table storing the list of REF values, and join that table back with the employee table.

You can create an index on REF values only if the REF is *scoped* or has a referential constraint. A scoped REF column stores pointers only to objects in a particular table. The REF values in table emp_tab_reflist point only to objects in table addr_tab, so you can create a scope constraint and an index on the REF column, as shown in Example 18–27.

Example 18–27 XPath Rewrite for an Out-Of-Line Collection, with Index on REFs

```
ALTER TABLE emp_tab_reflist ADD SCOPE FOR (COLUMN_VALUE) IS addr_tab;
CREATE INDEX reflist_idx ON emp_tab_reflist (COLUMN_VALUE);
```

The explain-plan fragment for the same query as in Example 18–26 shows that index reflist_idx is picked up.

```
|   4 |    TABLE ACCESS BY INDEX ROWID| EMP_TAB_REFLIST |     1 |    20 |     1   (0)| 00:00:01 |
|*  5 |     INDEX RANGE SCAN          | REFLIST_IDX     |     1 |       |     0   (0)| 00:00:01 |
|   6 |   TABLE ACCESS BY INDEX ROWID | EMP_TAB         |       |       |            |          |
|*  7 |    INDEX UNIQUE SCAN          | SYS_C005567     |     1 |       |     0   (0)| 00:00:01 |
```

Considerations for Working with Complex or Large XML Schemas

XML schemas can be complex. Examples include recursive schemas and those that contain circular or cyclical references. XML schemas can also be quite large. This section covers the challenge of working with complex or large XML schemas.

Working with Circular and Cyclical Dependencies Among XML Schemas

The W3C XML Schema Recommendation lets complexTypes and global elements contain recursive references. For example, a complexType definition can *contain* an element based on that same complexType, or a global element can contain a reference to itself. In both cases the reference can be direct or indirect. This kind of structure allows for instance documents where the element in question can appear an infinite number of times in a recursive hierarchy.

Example 18–28 An XML Schema with Circular Dependency

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xs:element name="person" type="personType" xdb:defaultTable="PERSON_TABLE"/>
  <xs:complexType name="personType" xdb:SQLType="PERSON_T">
    <xs:sequence>
      <xs:element name="descendant" type="personType" minOccurs="0"
                  maxOccurs="unbounded" xdb:SQLName="DESCENDANT"
                  xdb:defaultTable="DESCENDANT_TABLE"/>
    </xs:sequence>
    <xs:attribute name="personName" use="required" xdb:SQLName="PERSON_NAME">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:maxLength value="20"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
  </xs:complexType>
</xs:schema>
```

The XML schema in Example 18–28 includes a circular dependency. The `complexType` `personType` consists of a `personName` attribute and a collection of `descendant` elements. The `descendant` element is defined as being of type `personType`.

For Circular XML Schema Dependencies Set Parameter GENTABLES to TRUE

Oracle XML DB supports XML schemas that define this kind of structure. It does this by detecting the cycles, breaking them, and storing the recursive elements as rows in a separate `XMLType` table that is created during XML schema registration.

Consequently, it is important to ensure that parameter `GENTABLES` is set to `TRUE` when registering an XML schema that defines this kind of structure. The name of the table used to store the recursive elements can be specified by adding an `xdb:defaultTable` annotation to the XML schema.

complexType Declarations XML Schema: Handling Cycles

SQL object types do not allow cycles. Cycles in an XML schema are broken while generating the object types, by introducing a `REF` attribute at the point where the cycle would be completed. Thus, part of the data is stored out of line, but it is still retrieved as part of the parent XML document.

> **Note:** Starting with Oracle Database 11g Release 2 (11.2.0.2), you can create only *one* `XMLType` table that uses an XML schema that results in `an out-of-line table`. An error is raised if you try to create a second table that uses the same XML schema.

XML schemas permit cycling between definitions of complex types. Figure 18–3 shows this, where the definition of complex type `CT1` can reference another complex type `CT2`, whereas the definition of `CT2` references the first type `CT1`.

XML schemas permit cycles among definitions of complex types. Example 18–29 creates a cycle of length two:

Example 18–29 XML Schema: Cycling Between complexTypes

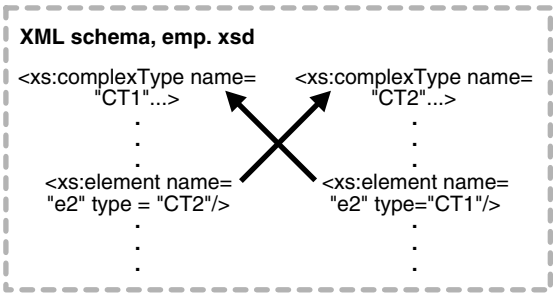
```
DECLARE
  doc VARCHAR2(3000) :=
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:complexType name="CT1" xdb:SQLType="CT1">
         <xs:sequence>
           <xs:element name="e1" type="xs:string"/>
           <xs:element name="e2" type="CT2"/>
         </xs:sequence>
       </xs:complexType>
       <xs:complexType name="CT2" xdb:SQLType="CT2">
         <xs:sequence>
           <xs:element name="e1" type="xs:string"/>
           <xs:element name="e2" type="CT1"/>
         </xs:sequence>
       </xs:complexType>
     </xs:schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/emp.xsd',
    SCHEMADOC => doc);
END;
```

SQL types do not allow cycles in type definitions. However, they do support **weak cycles**, that is, cycles involving `REF` (reference) object attributes. Cyclic XML schema definitions are mapped to SQL object types in such a way that cycles are avoided by forcing `SQLInline = "false"` at the appropriate points. This creates a weak SQL cycle.

For the XML schema of Example 18–29, Oracle XML DB generates the following types:

```
CREATE TYPE ct1 AS OBJECT (SYS_XDBPD$  XDB.XDB$RAW_LIST_T,
                           "e1"        VARCHAR2(4000),
                           "e2"        REF XMLType) NOT FINAL;
CREATE TYPE ct2 AS OBJECT (SYS_XDBPD$  XDB.XDB$RAW_LIST_T,
                           "e1"        VARCHAR2(4000),
                           "e2"        CT1) NOT FINAL;
```

Figure 18–3 Cross Referencing Between Different complexTypes in the Same XML Schema



Another example of a cyclic complex type involves the declaration of the complex type that refers to itself. In Example 18–30, type `SectionT` does this.

Example 18–30 XML Schema: Cycling Between complexTypes, Self-Reference

```
DECLARE
  doc VARCHAR2(3000) :=
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:complexType name="SectionT" xdb:SQLType="SECTION_T">
         <xs:sequence>
           <xs:element name="title" type="xs:string"/>
           <xs:choice maxOccurs="unbounded">
             <xs:element name="body" type="xs:string"
                         xdb:SQLCollType="BODY_COLL"/>
             <xs:element name="section" type="SectionT"/>
           </xs:choice>
         </xs:sequence>
       </xs:complexType>
     </xs:schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/section.xsd',
    SCHEMADOC => doc);
END;
```

For the XML schema of Example 18–30, Oracle XML DB generates the following types:

```
CREATE TYPE body_coll AS VARRAY(32767[6]) OF VARCHAR2(32767[6]);
```

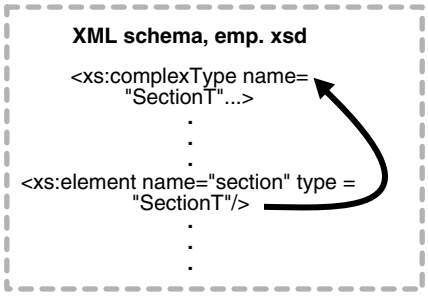
[6] This value of 32767 assumes that the value of initialization parameter `MAX_STRING_SIZE` is `EXTENDED`. See *Oracle Database SQL Language Reference*.

```
CREATE TYPE section_t AS OBJECT (SYS_XDBPD$  XDB.XDB$RAW_LIST_T,
                                 "title"     VARCHAR2(32767[6]),
                                 "body"      BODY_COLL,
                                 "section"   XDB.XDB$REF_LIST_T) NOT FINAL;
```

Note: In Example 18–30, object attribute `section` is declared as a varray of `REF` references to `XMLType` instances. Because there can be more than one occurrence of embedded sections, the attribute is a varray. It is a varray of `REF` references to `XMLType` instances, to avoid forming a cycle of SQL objects.

Figure 18–4 illustrates schematically how a `complexType` can reference itself.

Figure 18–4 Self-Referencing Complex Type within an XML Schema



See Also: "Cyclical References Among XML Schemas" on page 18-44

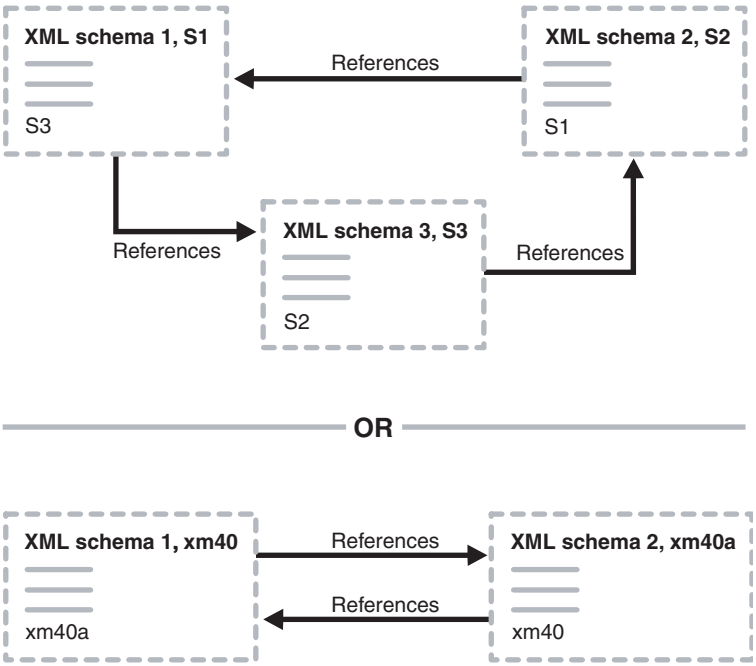
Cyclical References Among XML Schemas

XML schemas can depend on each other in such a way that they cannot be registered one after the other in the usual manner. Illustrations of such XML schemas follow in Figure 18–5.

In the top half of the illustration, an example of indirect cyclical references between three XML schemas is shown.

In the bottom half of the illustration, an example of cyclical dependencies between two XML schemas is shown. The details of this simpler example are presented first.

Figure 18–5 Cyclical References Between XML Schemas



An XML schema that includes another XML schema cannot be created if the included XML schema does not exist. The registration of XML schema `xm40.xsd` in Example 18–31 fails, if `xm40a.xsd` does not exist.

Example 18–31 An XML Schema that Includes a Non-Existent XML Schema

```
BEGIN DBMS_XMLSCHEMA.registerSchema(
  SCHEMAURL => 'xm40.xsd',
  SCHEMADOC => '<schema xmlns="http://www.w3.org/2001/XMLSchema"
                        xmlns:my="xm40"
                        targetNamespace="xm40">
                  <include schemaLocation="xm40a.xsd"/>
                  <!-- Define a global complextype here -->
                  <complexType name="Company">
                    <sequence>
                      <element name="Name" type="string"/>
                      <element name="Address" type="string"/>
                    </sequence>
                  </complexType>
                  <!-- Define a global element depending on included schema -->
                  <element name="Emp" type="my:Employee"/>
                </schema>',
  LOCAL     => TRUE,
  GENTYPES  => TRUE,
  GENTABLES => TRUE);
END;
/
```

XML schema `xm40.xsd` can, however, be created if you specify option `FORCE => TRUE`, as in Example 18–32:

Example 18–32 Using the FORCE Option to Register XML Schema xm40.xsd

```
BEGIN DBMS_XMLSCHEMA.registerSchema(
  SCHEMAURL => 'xm40.xsd',
```

```
  SCHEMADOC => '<schema xmlns="http://www.w3.org/2001/XMLSchema"
                        xmlns:my="xm40"
                        targetNamespace="xm40">
                  <include schemaLocation="xm40a.xsd"/>
                  <!-- Define a global complextype here -->
                  <complexType name="Company">
                    <sequence>
                      <element name="Name" type="string"/>
                      <element name="Address" type="string"/>
                    </sequence>
                  </complexType>
                  <!-- Define a global element depending on included schema -->
                  <element name="Emp" type="my:Employee"/>
                </schema>',
  LOCAL     => TRUE,
  GENTYPES  => TRUE,
  GENTABLES => TRUE,
  FORCE     => TRUE);
END;
/
```

However, an attempt to use XML schema `xm40.xsd`, as in Example 18–33, fails.

Example 18–33 Trying to Create a Table Using a Cyclic XML Schema

```
CREATE TABLE foo OF XMLType XMLSCHEMA "xm40.xsd" ELEMENT "Emp";
```

If you register `xm40a.xsd` using the `FORCE` option, as in Example 18–34, then both XML schemas can be used, as shown by the `CREATE TABLE` statements.

Example 18–34 Using the FORCE Option to Register XML Schema xm40a.xsd

```
BEGIN DBMS_XMLSCHEMA.registerSchema(
  SCHEMAURL => 'xm40a.xsd',
  SCHEMADOC => '<schema xmlns="http://www.w3.org/2001/XMLSchema"
                        xmlns:my="xm40"
                        targetNamespace="xm40">
                  <include schemaLocation="xm40.xsd"/>
                  <!-- Define a global complextype here -->
                  <complexType name="Employee">
                    <sequence>
                      <element name="Name" type="string"/>
                      <element name="Age" type="positiveInteger"/>
                      <element name="Phone" type="string"/>
                    </sequence>
                  </complexType>
                  <!-- Define a global element depending on included schema -->
                  <element name="Comp" type="my:Company"/>
                </schema>',
  LOCAL     => TRUE,
  GENTYPES  => TRUE,
  GENTABLES => TRUE,
  FORCE     => TRUE);
END;
/

CREATE TABLE foo  OF XMLType XMLSCHEMA "xm40.xsd"  ELEMENT "Emp";
CREATE TABLE foo2 OF XMLType XMLSCHEMA "xm40a.xsd" ELEMENT "Comp";
```

Thus, to register these XML schemas, which depend on each other, you must use the FORCE parameter in DBMS_XMLSCHEMA.registerSchema for each schema, as follows:

1. Register xm40.xsd with FORCE mode set to TRUE:

   ```
   DBMS_XMLSCHEMA.registerSchema("xm40.xsd", "<schema ...", ..., FORCE => TRUE)
   ```

   At this point, xm40.xsd *cannot* be used.

2. Register xm40a.xsd in FORCE mode set to TRUE:

   ```
   DBMS_XMLSCHEMA.registerSchema("xm40a.xsd", "<schema ...", ..., FORCE => TRUE)
   ```

   The second operation automatically compiles xm40.xsd and makes both XML schemas usable.

Support for Recursive Schemas

Storing a REF to a recursive structure that is in an out-of-line table has the disadvantage that XPath queries against such documents cannot easily be rewritten, because it is not known at compile time how deep the structure might be. To enable rewrite of such XPath queries, a DOCID column is used to store a pointer back to the root document in any recursive structure, enabling some queries to use the out-of-line tables directly and join back using this column.

Example 18–35 shows a recursive XML schema.

Example 18–35 Recursive XML Schema

```
<schema targetNamespace="AbcNS" xmlns="http://www.w3.org/2001/XMLSchema"
          xmlns:abc="AbcNS" xmlnm:xdb="http://xmlns.oracle.com.xdb">
  <element name="AbcCode" xdb:defaultTable="ABCCODETAB">
    <complexType>
      <sequence>
        <element ref="abc:AbcSection"/>
      </sequence>
    </complexType>
  </element>

  <element name="AbcSection">
    <complexType>
      <sequence>
        <element name="ID" type="integer"/>
        <element name="Contents" type="string"/>
        <element ref="abc:AbcSection"/>
      </sequence>
    </complexType>
  </element>
</schema>
```

A **document-correlated recursive query** is a query using a SQL function that accepts an XPath or XQuery expression and an XMLType instance, where that XPath or XQuery expression contains '//'. A document-correlated recursive query can be *rewritten* if it can be determined at query compilation time that both of the following conditions are met:

- All fragments of the XMLType instance that are targeted by the XPath or XQuery expression reside in a single out-of-line table.
- No other fragments of the XMLType instance reside in the same out-of-line table.

The rewritten query is a join with the out-of-line table, based on the DOCID column.

Other queries with '//' can also be rewritten. For example, if there are several address elements, all of the same type, in different sections of a schema, and you often query all address elements with '//', not caring about their specific location in the document, rewrite can occur.

During schema registration, an additional DOCID column is generated for out-of-line XMLType tables This column stores the OID (Object Identifier Values) of the document, that is, the root element. This column is automatically populated when data is inserted in the tables. You can export tables containing DOCID columns and import them later.

Sharing defaultTable Among Common Out-Of-Line Elements

The out-of-line elements of the same qualified name (namespace and local name) and same type are stored in the same default table. As a special case, you can store the root element of a cyclic element structure out of line also, and in the same table as the sub-elements (if the root element is stored out of line also).

Both of the elements sharing the default table must be out-of-line elements, that is, the default table for an out-of-line element cannot be the same as the table for a top-level element. To do this, specify xdb:SQLInline = "false" for both elements and specify an explicit xdb:defaultTable attribute having the same value in both elements.

Example 18–36 shows an XML schema with an out-of-line table that is stored in ABCSECTIONTAB.

Example 18–36 Out-of-line Table

```
<schema targetNamespace="AbcNS" xmlns="http://www.w3.org/2001/XMLSchema"
          xmlns:abc="AbcNS" xmlns:xdb="http://xmlns.oracle.com/xdb">
  <element name="AbcCode" xdb:defaultTable="ABCCODETAB">
    <complexType>
      <sequence>
        <element ref="abc:AbcSection" xdb:SQLInline="false"/>
      </sequence>
    </complexType>
  </element>

  <element name="AbcSection" xdb:defaultTable="">
    <complexType>
      <sequence>
        <element name="ID" type="integer"/>
        <element name="Contents" type="string"/>
        <element ref="abc:AbcSection" xdb:SQLInline="false"
                 xdb:defaultTable="ABCSECTIONTAB"/>
      </sequence>
    </complexType>
  </element>
</schema>
```

Both of the out-of-line AbcSection elements in Example 18–36 share the same default table, ABCSECTIONTAB.

However, the Example 18–37 illustrates *invalid* default table sharing: recursive elements (XyZSection) do not share the same out-of-line table.

Example 18–37 Invalid Default Table Sharing

```
<schema targetNamespace="XyzNS" xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xyz="XyzNS" xmlns:xdb="http://xmlns.oracle.com/xdb">
  <element name="XyzCode" xdb:defaultTable="XYZCODETAB">
  <complexType>
```

```
   <sequence>
      <element name="CodeNumber" type="integer" minOccurs="0"/>
      <element ref="xyz:XyzChapter" xdb:SQLInline="false"/>
      <element ref="xyz:XyzPara" xdb:SQLInline="false" />
   </sequence>
   </complexType>
   </element>

    <element name="XyzChapter" xdb:defaultTable="XYZCHAPTAB">
     <complexType>
     <sequence>
         <element name="Title" type="string"/>
         <element ref="xyz:XyzSection" xdb:SQLInline="false"
                  xdb:defaultTable="XYZSECTIONTAB"/>
      </sequence>
      </complexType>
    </element>

    <element name="XyzPara" xdb:defaultTable="XYZPARATAB">
     <complexType>
     <sequence>
         <element name="Title" type="string"/>
         <element ref="xyz:XyzSection" xdb:SQLInline="false"
                  xdb:defaultTable="Other_XYZSECTIONTAB"/>
      </sequence>
      </complexType>
    </element>

    <element name="XyzSection">
    <complexType>
    <sequence>
        <element name="ID" type="integer"/>
        <element name="Contents" type="string"/>
        <element ref="xyz:XyzSection" xdb:defaultTable="XYZSECTIONTAB"/>
     </sequence>
     </complexType>
    </element>
 </schema>
```

The following query cannot be rewritten.

```
SELECT XMLQuery('//XyzSection' PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM xyzcode;
```

Query Rewrite when DOCID is Present

Before processing `//` XPath expressions, check to find multiple occurrences of the same element. If all occurrences under the `//` share the same `defaultTable`, then the query can be rewritten to go against that table, using the `DOCID`. If there are other occurrences of the same element under the root sharing that table, but not under `//`, then the query cannot be rewritten. For example, consider this element structure:

`<Book>` contains a `<Chapter>` and a `<Part>`. `<Part>` contains a `<Chapter>`.

Assume that both of the `<Chapter>` elements are stored out of line and they share the same default table. The query `/Book//Chapter` can be rewritten to go against the default table for the `<Chapter>` elements because all of the `<Chapter>` elements under `<Book>` share the same default table. Thus, this XPath query is a document-correlated recursive XPath query.

However, a query such as /Book/Part//Chapter cannot be rewritten, even though all the <Chapter> elements under <Part> share the same table, because there is another <Chapter> element under <Book>, which is the document root that also shares that table.

Consider the case where you are extracting //AbcSection with DOCID present, as in the XML schema described in Example 18–36:

```
SELECT XMLQuery('//AbcSection' PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM abccodetab;
```

Both of the AbcSection elements are stored in the same table, abcsectiontab. The extraction applies to the underlying table, abcsectiontab.

Consider this query when DOCID is present:

```
SELECT XMLQuery('/AbcCode/AbcSection//AbcSection'
                PASSING OBJECT_VALUE RETURNING CONTENT)
  FROM abccodetab;
```

In both this case and the previous case, all reachable AbcSection elements are stored in the same out-of-line table. However, the first AbcSection element at /AbcCode/AbcSection cannot be retrieved by this query. Since the join condition is a DOCID, which cannot distinguish between different positions in the parent document, the correct result cannot be achieved by a direct query on table abcsectiontab. In this case, query rewrite does not occur since it is not a document-correlated recursive XPath. If this top-level AbcSection were not stored out of line with the rest, then the query could be rewritten.

Disabling DOCID Column Creation

You can disable the creation of column DOCID by specifying an OPTIONS parameter when calling DBMS_XMLSCHEMA.registerSchema. This disables DOCID creation in all XMLType tables generated during schema registration.

The OPTIONS parameter is an input parameter of data type PLS_INTEGER. Its default value is 0, meaning no options are used. To inhibit generation of column DOCID, set parameter OPTIONS to DBMS_XMLSCHEMA.REGISTER_NODOCID (which is 1).

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Mapping XML Fragments to Large Objects (LOBs)

You can specify the SQL data type to use for a complex element as being CLOB or BLOB. In Figure 18–6, for example, an entire XML fragment is stored in a LOB attribute. This is useful when parts of an XML document are typically retrieved and stored as whole, and are seldom queried. By storing XML fragments as LOBs, you can save on parsing, decomposition, and recomposition overheads.

In Example 18–38, the XML schema defines element Addr using the annotation SQLType = "CLOB":

Example 18–38 Oracle XML DB XML Schema: Mapping complexType XML Fragments to LOBs

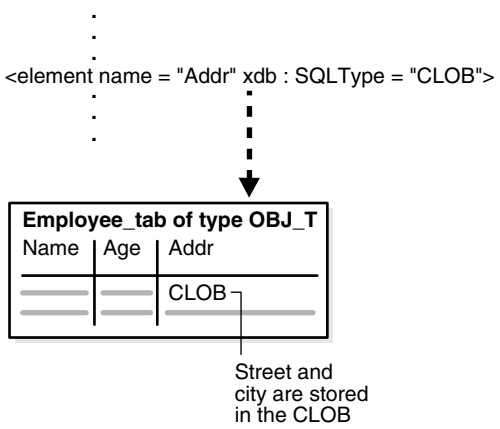
```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp.xsd"
             xmlns:emp="http://www.oracle.com/emp.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
```

```
      <complexType name="Employee" xdb:SQLType="OBJ_T">
        <sequence>
          <element name="Name" type="string"/>
          <element name="Age" type="decimal"/>
          <element name="Addr" xdb:SQLType="CLOB">
            <complexType >
              <sequence>
                <element name="Street" type="string"/>
                <element name="City" type="string"/>
              </sequence>
            </complexType>
          </element>
        </sequence>
      </complexType>
    </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://www.oracle.com/PO.xsd',
    SCHEMADOC => doc);
END;
```

When registering this XML schema, Oracle XML DB generates the following types and `XMLType` tables:

```
CREATE TYPE obj_t AS OBJECT(SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                            Name VARCHAR2(4000),
                            Age NUMBER,
                            Addr CLOB);
```

Figure 18–6 Mapping complexType XML Fragments to CLOB Instances



Issues with Large XML Schemas

Several issues can arise when working with large, complex XML schemas. Sometimes, you encounter one of these errors when you register an XML schema or you create a table that is based on a global element defined by an XML schema:

- `ORA-01792: maximum number of columns in a table or view is 1000`
- `ORA-04031: unable to allocate` *`string`* `bytes of shared memory ("`*`string`*`","`*`string`*`","`*`string`*`","`*`string`*`")`

These errors are raised when an attempt is made to create an `XMLType` table or column based on a global element and the global element is defined as a `complexType` that contains a very large number of element and attribute definitions.The errors are raised

only when creating an XMLType table or column that uses object-relational storage. In this case, the table or column is persisted using a SQL type, and each object attribute defined by the SQL type counts as one column in the underlying table. If the SQL type contains object attributes that are based on other SQL types, then the attributes defined by those types also count as columns in the underlying table.

If the total number of object attributes in all of the SQL types exceeds the Oracle Database limit of 1000 columns in a table, then the storage table cannot be created. When the total number of elements and attributes defined by a complexType reaches 1000, it is not possible to create a single table that can manage the SQL objects that are generated when an instance of that type is stored in the database.

> **Tip:** You can use the following query to determine the number of columns for a given XMLType table stored object-relationally:
>
> ```
> SELECT count(*) FROM USER_TAB_COLS WHERE TABLE_NAME = '<the table>'
> ```
>
> where *<the table>* is the table you want to check.

Error ORA-01792 reports that the 1000-column limit has been exceeded. Error ORA-04031 reports that memory is insufficient during the processing of a large number of element and attribute definitions.To resolve this problem of having too many element and attribute definitions, you must reduce the total number of object attributes in the SQL types that are used to create the storage tables.

There are two ways to achieve this reduction:

- Use a top-down technique, with *multiple* XMLType *tables* that manage the XML documents. This reduces the number of SQL attributes in the SQL type hierarchy for a given storage table. As long as none of the tables need to manage more than 1000 object attributes, the problem is resolved.
- Use a bottom-up technique, which reduces the number of SQL attributes in the SQL type hierarchy, *collapsing some elements and attributes* defined by the XML schema so that they are stored as a single CLOB value.

Both techniques rely on annotating the XML schema to define how a particular complexType is stored in the database.

For the top-down technique, annotations SQLInline = "false" and defaultTable force some subelements in the XML document to be stored as rows in a separate XMLType table. Oracle XML DB maintains the relationship between the two tables using a REF of XMLType. Good candidates for this approach are XML schemas that do either of the following:

- Define a *choice*, where each element within the choice is defined as a complexType
- Define an element based on a complexType that contains a *large number of element and attribute definitions*

The bottom-up technique involves reducing the total number of attributes in the SQL object types by choosing to store some of the lower-level complexType elements as CLOB values, rather than as objects. This is achieved by annotating the complexType or the usage of the complexType with SQLType = "CLOB".

Which technique you use depends on the application and the type of queries and updates to be performed against the data.

Considerations for Loading and Retrieving Large Documents with Collections

Oracle XML DB configuration file `xdbconfig.xml` has parameters that control the amount of memory used by the loading operation. These let you optimize the loading process, provided the following conditions are met:

- The document is loaded using one of the following:
  - Protocols (FTP, HTTP(S), or DAV)
  - PL/SQL function `DBMS_XDB_REPOS.createResource`
  - A SQL `INSERT` statement into an `XMLType` table (but not an `XMLType` column)
- The document is XML schema-based and contains large collections (elements with `maxOccurs` set to a large number).
- Collections in the document are stored as OCTs. This is the default behavior.

In the following situations, these optimizations are sometimes suboptimal:

- When there are triggers on the base table.
- When the base table is partitioned.
- When collections are stored out of line (applies only to SQL `INSERT`).

The basic idea behind this optimization is that it lets the collections be swapped into or out of the memory in bounded sizes. As an illustration of this idea consider the following example conforming to a purchase-order XML schema:

```
<PurchaseOrder>
  <LineItem itemID="1">
    ...
  </LineItem>
    .
    .
  <LineItem itemID="10240">
    ...
  </LineItem>
</PurchaseOrder>
```

The purchase-order document here contains a collection of 10240 `LineItem` elements. Creating the entire document in memory and then pushing it out to disk can lead to excessive memory usage and in some instances a load failure due to inadequate system memory. To avoid that, you can create the documents in finite chunks of memory called **loadable units**.

In the example case, assume that each line item needs 1 KB of memory and that you want to use loadable units of 512 KB each. Each loadable unit then contains 512 line items, and there are approximately 20 such units. If you want the entire memory representation of the document to never exceed 2 MB, then you must ensure that at any time no more than 4 loadable units are maintained in the memory. You can use an LRU mechanism to swap out the loadable units.

By controlling the size of the loadable unit and the bound on the size of the document you can tune the memory usage and performance of the load or retrieval. Typically a larger loadable unit size translates into lesser number of disk accesses but takes up more memory. This is controlled by configuration parameter `xdbcore-loadableunit-size`, whose default value is 16 KB. You can indicate the amount of memory to be given to a document by setting parameter `xdbcore-xobmem-bound`, which defaults to 1 MB. The values of these parameters are specified in kilobytes. So, the default value of `xdbcore-xobmem-bound` is 1024 and that

of xdbcore-loadableunit-size is 16. These are soft limits that provide some guidance to the system as to how to use the memory optimally.

When a document is loaded using FTP, the pattern in which the loadable units (LU) are created and flushed to the disk is as follows:

```
No LUs
Create LU1[LineItems(LI):1-512]
LU1[LI:1-512], Create LU2[LI:513-1024]
.
.
LU1[LI:1-512],...,Create LU4[LI:1517:2028]    <-   Total memory size = 2M
Swap Out LU1[LI:1-512], LU2[LI:513-1024],...,LU4[LI:1517-2028], Create
LU5[LI:2029-2540]
Swap Out LU2[LI:513-1024], LU3, LU4, LU5, Create LU6[LI:2541-2052]
.
.
.
Swap Out LU16, LU17, LU18, LU10, Create LU20[LI:9729-10240]
Flush LU17,LU18,LU19,LU20
```

Guidelines for Setting xdbcore Parameters

Typically, if you have 1 GB of addressable PG then give about 1/10th of PGA to the document. Set xobcore-xobmem-bound to 1/10 of addressable PGA, which is 100M. During full document retrievals and loads, xdbcore-loadableunit-size should be as close to xobcore-xobmem-bound as possible.

Start by setting xdbcore-loadableunit-size to half the value of xdbcore-xobmem-bound (50 MB). Then try to load the document.

If you run out of memory then reduce the value of xdbcore-xobmem-bound and set xdbcore-loadableunot-size to half of that value. Continue this way until the documents load successfully.

If the load operation succeeds then try to increase xdbcore-loadableunit-size, to obtain better performance. If xdbcore-loadableunit-size equals xdbcore-xobmem-bound, then try to increase both parameter values for further performance improvements.

Debugging XML Schema Registration for XML Data Stored Object-Relationally

For XML data stored object-relationally, you can monitor the object types and tables created during XML schema registration by setting the following event before invoking PL/SQL procedure DBMS_XMLSCHEMA.registerSchema:

```
ALTER SESSION SET EVENTS = '31098 TRACE NAME CONTEXT FOREVER'
```

Setting this event causes the generation of a log of all of the CREATE TYPE and CREATE TABLE statements. This log is written to the user session trace file, typically found in ORACLE_BASE/diag/rdbms/ORACLE_SID/ORACLE_SID/udump. This script can be a useful aid in diagnosing problems during XML schema registration.

19

XPath Rewrite for Object-Relational Storage

This chapter explains the fundamentals of XPath rewrite for object-relational storage of `XMLType` data in Oracle XML DB. It details the rewriting of XPath-expression arguments to various SQL functions.

This chapter contains these topics:

- Overview of XPath Rewrite for Object-Relational Storage
- Examples of XPath Expressions that Are Rewritten
- Guidelines for Using Execution Plans to Analyze and Optimize XPath Queries

See Also: "Performance Tuning for XQuery" on page 5-39

Overview of XPath Rewrite for Object-Relational Storage

Oracle XML DB can often optimize queries that use XPath expressions—for example, queries involving SQL functions such as `XMLQuery`, `XMLTable`, and `XMLExists`, which take XPath (XQuery) expressions as arguments. The XPath expression is, in effect, evaluated against the XML document without ever constructing the XML document in memory.

This optimization is called **XPath rewrite**. It is a proper subset of XML query optimization, which also involves optimization of XQuery expressions, such as FLWOR expressions, that are not XPath expressions. XPath rewrite also enables indexes, if present on the column, to be used in query evaluation by the Optimizer.

The XPath expressions that can be rewritten by Oracle XML DB are a proper subset of those that are supported by Oracle XML DB. Whenever you can do so without losing functionality, use XPath expressions that can be rewritten.

XPath rewrite can occur in these contexts (or combinations thereof):

- When `XMLType` data is stored in an object-relational column or table or when an `XMLType` view is built on relational data.

  See Also:

  - Chapter 9, "Relational Views over XML Data"
  - Chapter 10, "XMLType Views"
  - "Indexing XMLType Data Stored Object-Relationally" on page 6-54

- When you use an `XMLIndex` index.

  See Also: "XMLIndex" on page 6-6

This chapter covers the first case: rewriting queries that use object-relational XML data or XMLType views. The XMLType views can be XML schema-based or not. Object-relational storage of XMLType data is always XML schema-based. Examples in this chapter are related to XML schema-based tables.

When XPath rewrite is possible for object-relational XML data, the database optimizer can derive an execution plan based on conventional relational algebra. This in turn means that Oracle XML DB can leverage all of the features of the database and ensure that SQL statements containing XQuery and XPath expressions are executed in a highly performant and efficient manner. There is little overhead with this rewriting, so Oracle XML DB executes XQuery-based and XPath-based queries at near-relational speed.

In certain cases, XPath rewrite is not possible. This typically occurs when there is no SQL equivalent of the XPath expression. In this situation, Oracle XML DB performs a functional evaluation of the XPath expressions, which is generally more costly, especially if the number of documents to be processed is large.

Example 19–1 illustrates XPath rewrite for a simple query that uses an XPath expression.

Example 19–1 XPath Rewrite

```
SELECT po.OBJECT_VALUE FROM purchaseorder po
  WHERE XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                         PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(128))
        = 'Sarah J. Bell';
```

The XMLCast(XMLQuery...)) expression here is rewritten to the underlying relational column that stores the requestor information for the purchase order. The query is rewritten to something like the following:[1]

```
SELECT OBJECT_VALUE FROM purchaseorder p
 WHERE CAST (p."XMLDATA"."REQUESTOR" AS VARCHAR2(128)) = 'Sarah J. Bell';
```

See Also: "XML Schema Annotation Guidelines for Object-Relational Storage" on page 18-14

Examples of XPath Expressions that Are Rewritten

Table 19–1 describes some XPath expressions that are rewritten during XPath rewrite.

[1] This example uses sample database schema OE and its table purchaseorder. The XML schema for this table is annotated with attribute SQLName to specify SQL object attribute names such as REQUESTOR—see Example A–2 on page A-34. Without such annotations, this example would use p."XMLDATA"."**Requestor**", not p."XMLDATA"."**REQUESTOR**".

Table 19–1 Sample of XPath Expressions that Are Rewritten to Underlying SQL Constructs

XPath Expression for Translation	Description

Simple XPath expressions (expressions with `child` and `attribute` axes only):
`/PurchaseOrder/@Reference`
`/PurchaseOrder/Requestor`
	Involves traversals over object type attributes only, where the attributes are simple scalar or object types themselves.

Collection traversal expressions: `/PurchaseOrder/LineItems/LineItem/Part/@Id`	Involves traversal of collection expressions. The only axes supported are child and attribute axes. Collection traversal is not supported if the SQL function is used during a `CREATE INDEX` operation.
Predicates: `[Requestor = "Sarah J. Bell"]`	Predicates in the XPath are rewritten into SQL predicates.
List index (positional predicate): `LineItem[1]`	Indexes are rewritten to access the nth item in a collection.
Wildcard traversals: `/PurchaseOrder/*/Part/@Id`	If the wildcard can be translated to one or more simple XPath expressions, then it is rewritten.
Descendant axis (XML schema-based data only), without recursion: `/PurchaseOrder//Part/@Id`	Similar to a wildcard expression. The `descendant` axis is rewritten if it can be mapped to one or more simple XPath expressions.
Descendant axis (XML schema-based data only), with *recursion*: `/PurchaseOrder//Part/@Id`	The `descendant` axis is rewritten if both of these conditions holds: ▪ All simple XPath expressions to which this XPath expression expands map to the same out-of-line table. ▪ Any simple XPath expression to which this XPath expression does not expand does not map to that out-of-line table.
XPath functions	Some XPath functions are rewritten. These functions include `not`, `floor`, `ceiling`, `substring`, and `string-length`.

See Also: "Performance Tuning for XQuery" on page 5-39 for information about rewrite of XQuery expressions

XPath Rewrite for Out-Of-Line Tables

XPath expressions that involve elements stored out of line can be automatically rewritten. The rewritten query involves a join with the out-of-line table. Example 19–2 shows such a query.

Example 19–2 XPath Rewrite for an Out-Of-Line Table

```
SELECT XMLCast(XMLQuery('declare namespace x = "http://www.oracle.com/emp.xsd"; (: :)
                         /x:Employee/Name' PASSING OBJECT_VALUE RETURNING CONTENT)
               AS VARCHAR2(20))
  FROM emp_tab
  WHERE XMLExists('declare namespace x = "http://www.oracle.com/emp.xsd"; (: :)
                   /x:Employee/Addr[City="San Francisco"]' PASSING OBJECT_VALUE);

XMLCAST(XMLQUERY(...
--------------------
Abe Bee
```

```
Eve Fong
George Hu
Iris Jones
Karl Luomo
Marina Namur
Omar Pinano
Quincy Roberts

8 rows selected.
```

The XQuery expression here is rewritten to a SQL `EXISTS` subquery that queries table `addr_tab`, joining it with table `emp_tab` using the object identifier column in `addr_tab`. The optimizer uses full table scans of tables `emp_tab` and `addr_tab`. If there are many entries in the `addr_tab`, then you can try to make this query more efficient by creating an index on the city, as shown in Example 19–3. An explain-plan fragment for the same query as in Example 19–2 shows that the city index is picked up.

Example 19–3 Using an Index with an Out-Of-Line Table

```
CREATE INDEX addr_city_idx
  ON addr_tab (extractValue(OBJECT_VALUE, '/Addr/City'));

|   2 |   TABLE ACCESS BY INDEX ROWID| ADDR_TAB      |     1 |  2012 |     1   (0)| 00:00:01 |
|*  3 |    INDEX RANGE SCAN          | ADDR_CITY_IDX |     1 |       |     1   (0)| 00:00:01 |
|   4 |   TABLE ACCESS FULL          | EMP_TAB       |    16 | 32464 |     2   (0)| 00:00:01 |
```

Note: When gathering statistics for the optimizer on an `XMLType` table that is stored object-relationally, Oracle recommends that you gather statistics on *all* of the tables defined by the XML schema, that is, all of the tables in `USER_XML_TABLES`. You can use procedure `DBMS_STATS.gather_schema_stats` to do this, or use `DBMS_STATS.gather_table_stats` on each such table. This informs the optimizer about all of the dependent tables that are used to store the `XMLType` data.

Guidelines for Using Execution Plans to Analyze and Optimize XPath Queries

This section presents some guidelines for using execution plans to do the following, for queries that use XPath expressions:

- Analyze query execution, to determine whether XPath rewrite occurs.
- Optimize query execution, by using secondary indexes.

Use these guidelines together, taking all that apply into consideration.

As is true also for the rest of this chapter, this section is applicable only to `XMLType` data that is stored object-relationally.

XPath rewrite for object-relational storage means that a query that selects XML fragments defined by an XPath expression is rewritten to a SQL `SELECT` statement on the underlying object-relational tables and columns. These underlying tables can include out-of-line tables.

You can use PL/SQL procedure `DBMS_XMLSTORAGE_MANAGE.XPath2TabColMapping` to find the names of the underlying tables and columns that correspond to a given XPath expression.

See Also:

- "XPath Rewrite for Out-Of-Line Tables" on page 19-3
- *Oracle Database PL/SQL Packages and Types Reference* for information about procedure `XPath2TabColMapping`

Guideline: Look for underlying tables versus XML functions in execution plans

The execution plan of a query that has been rewritten refers to the object-relational tables and columns that underlie the queried `XMLType` data.

The names of the underlying tables can be meaningful to you, if they are derived from XML element or attribute names or if the governing XML schema explicitly names them by using annotation `xdb:defaultTable`. Otherwise, these names are system-generated and have no obvious meaning. In particular, they do not reflect the corresponding XML element or attribute names. Also, some system-generated columns are hidden. You do not see them if you use the SQL `describe` command. They nevertheless show up in execution plans.

The plan of a query that has not been rewritten shows only the base table names, and it typically refers to user-level XML functions, such as `XMLExists`. Look for this difference to determine whether a query has been optimized. The XML function name shown in an execution plan is actually the internal name (for example, `XMLEXISTS2`), which is sometimes slightly different from the user-level name.

Example 19–4 shows the kind of execution plan output that is generated when Oracle XML DB cannot perform XPath rewrite. The plan here is for a query that uses SQL/XML function `XMLExists`. The corresponding internal function `XMLExists2` appears in the plan output, indicating that the query is not rewritten.

Example 19–4 Execution Plan Generated When XPath Rewrite Does Not Occur

```
Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter(XMLEXISTS2('$p/PurchaseOrder[User="SBELL"]' PASSING BY VALUE
              SYS_MAKEXML('61687B202644E297E040578C8A175C1D',4215,"PO"."XMLEXTRA","PO"."X
              MLDATA") AS "p")=1)
```

In this situation, Oracle XML DB constructs a pre-filtered result set based on any other conditions specified in the query `WHERE` clause. It then filters the rows in this potential result set to determine which rows belong in the result set. The filtering is performed by *constructing a DOM on each document* and performing a **functional evaluation** using the methods defined by the DOM API to determine whether or not each document is a member of the result set.

Guideline: Name the object-relational tables, so you recognize them in execution plans

When designing an XML schema, use annotation `xdb:defaultTable` to name the underlying tables that correspond to elements that you select in queries where performance is important. This lets you easily recognize them in an execution plan, indicating by their presence or absence whether the query has been rewritten.

For collection tables, there is no corresponding XML schema annotation. To give user-friendly names to your collection tables you must first register the XML schema. Then you can use PL/SQL procedure `DBMS_XMLSTORAGE_MANAGE.renameCollectionTable` to rename the tables that were created during registration, which have system-generated names.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for information about procedure `renameCollectionTable`

Guideline: Create an index on a column targeted by a predicate

A query resulting from XPath rewrite sometimes includes a SQL predicate (`WHERE` clause). This can happen even if the original query does not use an XPath predicate, and it can happen even if the original query does not have a SQL `WHERE` clause.

When this happens, you can sometimes improve performance by creating an index on the column that is targeted by the SQL predicate, or by creating an index on a function application to that column. Example 19–1 illustrates XPath rewrite for a query that includes a `WHERE` clause. Example 19–5 shows the predicate information from an execution plan for this query.

Example 19–5 Analyzing an Execution Plan to Determine a Column to Index

```
Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter(CAST("PURCHASEORDER"."SYS_NC00021$" AS VARCHAR2(128))='Sarah
              J. Bell' AND SYS_CHECKACL("ACLOID","OWNERID",xmltype('<privilege
              xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
              xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
              xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
              http://xmlns.oracle.com/xdb/acl.xsd DAV:http://xmlns.oracle.com/xdb/dav.xsd
              "><read-properties/><read-contents/></privilege>'))=1)
```

The predicate information indicates that the expression `XMLCast(XMLQuery...))` is rewritten to an application of SQL function `cast` to the underlying relational column that stores the requestor information for the purchase order, `SYS_NC0021$`. This column name is system-generated. The execution plan refers to this system-generated name, in spite of the fact that the governing XML schema uses annotation `SQLName` to name this column `REQUESTOR`.

Because these two names (user-defined and system-generated) refer to the same column, you can create a B-tree index on this column using either name. Alternatively, you can use the `extractValue` shortcut to create the index, by specifying an XPath expression that targets the purchase-order requestor data.

You can obtain the names of the underlying table and columns that correspond to a given XPath expression using procedure `DBMS_XMLSTORAGE_MANAGE.XPath2TabColMapping`. Example 19–6 illustrates this for the XPath expression `/PurchaseOrder/Requestor` used in the `WHERE` clause of Example 19–1.

Example 19–6 Using DBMS_XMLSTORAGE_MANAGE.XPATH2TABCOLMAPPING

```
SELECT DBMS_XMLSTORAGE_MANAGE.XPath2TabColMapping(USER,
                                                  'PURCHASEORDER',
                                                  '',
                                                  '/PurchaseOrder/Requestor',
                                                  '')
  FROM  DUAL;

DBMS_XMLSTORAGE_MANAGE.XPath2TabColMapping(US
---------------------------------------------
<Result>
  <Mapping TableName="PURCHASEORDER" ColumnName="SYS_NC00021$"/>
</Result>
```

If you provide an XPath expression that contains a wildcard or a descendent axis then multiple tables and columns might be selected. In that case procedure `XPath2TabColMapping` returns multiple `<Mapping>` elements, one for each table-column pair.

You can then use the table and column names retrieved this way in a `CREATE INDEX` statement to create an index that corresponds to the XPath expression. Example 19–7 shows three equivalent ways to create a B-tree index on the predicate-targeted column.

Example 19–7 Creating an Index on a Column Targeted by a Predicate

```
CREATE INDEX requestor_index ON purchaseorder ("SYS_NC00021$");

CREATE INDEX requestor_index ON purchaseorder ("XMLDATA"."REQUESTOR");

CREATE INDEX requestor_index ON purchaseorder
  (extractvalue(OBJECT_VALUE, '/PurchaseOrder/Requestor'));
```

However, for this particular query it makes sense to create a function-based index, using a functional expression that matches the one in the rewritten query. Example 19–8 illustrates this.

Example 19–8 Creating a Function-Based Index for a Column Targeted by a Predicate

```
CREATE INDEX requestor_index ON purchaseorder
  (cast("XMLDATA"."REQUESTOR" AS VARCHAR2(128)));
```

Example 19–9 shows an execution plan that indicates that the index is picked up.

Example 19–9 Execution Plan Showing that Index Is Picked Up

```
-----------------------------------------------------------------------------------------------
| Id  | Operation                    | Name            | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |                 |     1 |   524 |     2   (0)| 00:00:01 |
|*  1 |  TABLE ACCESS BY INDEX ROWID| PURCHASEORDER   |     1 |   524 |     2   (0)| 00:00:01 |
|*  2 |   INDEX RANGE SCAN           | REQUESTOR_INDEX |     1 |       |     1   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter(SYS_CHECKACL("ACLOID","OWNERID",xmltype('<privilege
              xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
              xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
              xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                  http://xmlns.oracle.com/xdb/acl.xsd
              DAV:http://xmlns.oracle.com/xdb/dav.xsd">
              <read-properties/><read-contents/></privilege>'))=1)
   2 - access(CAST("SYS_NC00021$" AS VARCHAR2(128))='Sarah J. Bell')
```

In the particular case of this query, the original functional expression applies `XMLCast` to `XMLQuery` to target a singleton element, `Requestor`. This is a special case, where you can as a shortcut use such a functional expression directly in the `CREATE INDEX` statement. That statement is rewritten to create an index on the underlying scalar data. Example 19–10, which targets an XPath expression, thus has the same effect as Example 19–8, which targets the corresponding object-relational column.

Example 19–10 Creating a Function-Based Index for a Column Targeted by a Predicate

```
CREATE INDEX requestor_index
  ON purchaseorder po
     (XMLCast(XMLQuery('$p/PurchaseOrder/Requestor' PASSING po.OBJECT_VALUE AS "p"
                                                    RETURNING CONTENT)
              AS VARCHAR2(128)));
```

See Also:

- "Indexing Non-Repeating Text Nodes or Attribute Values" on page 6-54 for information about using the shortcut of `XMLCast` applied to `XMLQuery` and the `extractValue` shortcut to index singleton data
- *Oracle Database PL/SQL Packages and Types Reference* for information about procedure `XPath2TabColMapping`

Guideline: Create indexes on ordered collection tables

If a collection is stored as an ordered collection table or an `XMLType` instance, then you can directly access members of the collection. Each member of the collection becomes a row in a table, so you can access it directly with SQL.

You can often improve performance by indexing such collection members. You do this by creating a *composite* index on (a) the object attribute that corresponds to the collection XML element or its attribute and (b) pseudocolumn `NESTED_TABLE_ID`.

Example 19–11 shows the execution plan for a query to find the `Reference` elements in documents that contain an order for part number 717951002372 (`Part` element with an `Id` attribute of value `717951002372`). The collection of `LineItem` elements is stored as rows in the ordered collection table `lineitem_table`.

Note: Example 19–11 does not use the `purchaseorder` table from sample database schema `OE`. It uses a `purchaseorder` table that uses an ordered collection table (OCT) named `lineitem_table` for the collection element `LineItem`.

Example 19–11 Execution Plan for a Selection of Collection Elements

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference'
                        PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(4000)) "Reference"
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/LineItems/LineItem/Part[@Id="717951002372"]'
                  PASSING OBJECT_VALUE AS "p");

-----------------------------------------------------------------------------------------------------
| Id  | Operation                    | Name                 | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |                      |    21 |  2352 |    20  (10)| 00:00:01 |
|*  1 |  HASH JOIN RIGHT SEMI        |                      |    21 |  2352 |    20  (10)| 00:00:01 |
|   2 |   JOIN FILTER CREATE         | :BF0000              |    22 |   880 |    14   (8)| 00:00:01 |
|*  3 |    TABLE ACCESS FULL         | LINEITEM_TABLE       |    22 |   880 |    14   (8)| 00:00:01 |
|   4 |   JOIN FILTER USE            | :BF0000              |   132 |  9504 |     5   (0)| 00:00:01 |
|*  5 |    TABLE ACCESS FULL         | PURCHASEORDER        |   132 |  9504 |     5   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------
   1 - access("NESTED_TABLE_ID"="PURCHASEORDER"."SYS_NC0003400035$")
```

```
   3 - filter("SYS_NC00011$"='717951002372')
   5 - filter(SYS_OP_BLOOM_FILTER(:BF0000,"PURCHASEORDER","SYS_NC0003400035$"))
```

The execution plan shows a full scan of ordered collection table `lineitem_table`. This could be acceptable if there were only a few hundred documents in the `purchaseorder` table, but it would be unacceptable if there were thousands or millions of documents in the table.

To improve the performance of such a query, you can create an index that provides direct access to pseudocolumn `NESTED_TABLE_ID`, given the value of attribute `Id`. Unfortunately, Oracle XML DB does not allow indexes on collections to be created using XPath expressions directly. To create the index, you must understand the structure of the SQL object that is used to manage the `LineItem` elements. Given this information, you can create the required index using conventional object-relational SQL.

In this case, element `LineItem` is stored as an instance of object type `lineitem_t`. Element `Part` is stored as an instance of SQL data type `part_t`. XML attribute `Id` is mapped to object attribute `part_number`. Given this information, you can create a *composite index* on attribute `part_number` and pseudocolumn `NESTED_TABLE_ID`, as shown in Example 19–12. This index provides direct access to those purchase-order documents that have `LineItem` elements that reference the required part.

Example 19–12 Creating an Index for Direct Access to an Ordered Collection Table

```
CREATE INDEX lineitem_part_index ON lineitem_table l (l.part.part_number, l.NESTED_TABLE_ID);
```

Guideline: Use XMLOptimizationCheck to determine why a query is not rewritten

If a query has not been optimized, you can use system variable `XMLOptimizationCheck` to try to determine why.

See Also: "Diagnosing XQuery Optimization: XMLOptimizationCheck" on page 5-45

20

XML Schema Evolution

This chapter describes how you can update your XML schema after you have registered it with Oracle XML DB. XML schema evolution is the process of updating your registered XML schema.

This chapter contains these topics:

- Overview of XML Schema Evolution
- Copy-Based Schema Evolution
- In-Place XML Schema Evolution

Oracle XML DB supports the W3C XML Schema recommendation. XML instance documents that conform to an XML schema can be stored and retrieved using SQL and protocols such as FTP, HTTP(S), and WebDAV. In addition to specifying the structure of XML documents, XML schemas determine the mapping between XML and object-relational storage.

See Also: Chapter 17, "XML Schema Storage and Query: Basic"

Overview of XML Schema Evolution

A major challenge for developers using an XML schema with Oracle XML DB is how to deal with changes in the content or structure of XML documents. In some environments, the need for changes may be frequent or extensive, arising from new regulations, internal needs, or external opportunities. For example, you might need to add new elements or attributes to an XML schema definition, modify a data type, or relax or tighten certain minimum and maximum occurrence requirements.

In such cases, you need to "evolve" the XML schema so that new requirements are accommodated, while any existing instance documents (the data) remain valid (or can be made valid), and existing applications can continue to run.

If you do not care about any existing documents, you can of course simply drop the `XMLType` tables that are dependent on the XML schema, delete the old XML schema, and register the new XML schema at the same URL. In most cases, however, you need to keep the existing documents, possibly transforming them to accommodate the new XML schema.

Oracle XML DB supports two kinds of schema evolution:

- **Copy-based schema evolution**, in which all instance documents that conform to the schema are copied to a temporary location in the database, the old schema is deleted, the modified schema is registered, and the instance documents are inserted into their new locations from the temporary area

- **In-place schema evolution**, which does not require copying, deleting, and inserting existing data and thus is much faster than copy-based evolution, but which has restrictions that do not apply to copy-based evolution

  In general, in-place evolution is permitted if you are not changing the storage model and if the changes do not invalidate existing documents (that is, if existing documents are conformant with the new schema or can be made conformant with it). A more detailed explanation of restrictions and guidelines is presented in "In-Place XML Schema Evolution" on page 20-15.

Each approach has its own PL/SQL procedure: `DBMS_XMLSCHEMA.copyEvolve` for copy-based evolution, `DBMS_XMLSCHEMA.inPlaceEvolve` for in-place evolution. This chapter explains the use of each procedure and presents guidelines for using its associated approach to schema evolution.

Copy-Based Schema Evolution

You perform copy-based XML schema evolution using procedure `copyEvolve` of PL/SQL package `DBMS_XMLSCHEMA`. Procedure `copyEvolve` copies existing instance documents to temporary `XMLType` tables to back them up, drops the old version of the XML schema (which also deletes the associated instance documents), registers the new version, and copies the backed-up instance documents to new `XMLType` tables. In case of a problem, the backup copies are restored—see "Rollback When Procedure DBMS_XMLSCHEMA.COPYEVOLVE Raises an Error" on page 20-9.

Using procedure `copyEvolve`, you can evolve your registered XML schema in such a way that existing XML instance documents continue to be valid.

Scenario for Copy-Based Evolution

Example 20–1 shows a *partial* listing of a revised version of the purchase-order XML schema of Example A–2 on page A-34. See Example A–3 on page A-37 for the *complete* revised schema listing. Text that is in **bold** here is new or different from that in the original schema.

Example 20–1 Revised Purchase-Order XML Schema

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0">
  <xs:element
    name="PurchaseOrder" type="PurchaseOrderType"
    xdb:defaultTable="PURCHASEORDER"
    xdb:columnProps=
      "CONSTRAINT purchaseorder_pkey PRIMARY KEY (XMLDATA.reference),
       CONSTRAINT valid_email_address FOREIGN KEY (XMLDATA.userid)
         REFERENCES hr.employees (EMAIL)"
    xdb:tableProps=
      "VARRAY XMLDATA.ACTIONS.ACTION STORE AS TABLE ACTION_TABLE
        ((CONSTRAINT action_pkey PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
       VARRAY XMLDATA.LINEITEMS.LINEITEM STORE AS TABLE LINEITEM_TABLE
        ((constraint LINEITEM_PKEY primary key (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
       lob (XMLDATA.NOTES) STORE AS (ENABLE STORAGE IN ROW STORAGE(INITIAL 4K NEXT 32K))"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="BillingAddress" type="AddressType" minOccurs="0"
```

```
                xdb:SQLName="BILLING_ADDRESS"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
      <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
      <xs:element name="Notes" type="NotesType" minOccurs="0" xdb:SQLType="CLOB"
                xdb:SQLName="NOTES"/>
    </xs:sequence>
    <xs:attribute name="Reference" type="ReferenceType" use="required" xdb:SQLName="REFERENCE"/>
    <xs:attribute name="DateCreated" type="xs:dateTime" use="required"
                xdb:SQLType="TIMESTAMP WITH TIME ZONE"/>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded" xdb:SQLName="LINEITEM"
                xdb:SQLCollType="LINEITEM_V"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
      <xs:element name="Quantity" type="quantityType"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                xdb:SQLType="NUMBER"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T">
    <xs:simpleContent>
      <xs:extension base="UPCCodeType">
        <xs:attribute name="Description" type="DescriptionType" use="required"
                  xdb:SQLName="DESCRIPTION"/>
        <xs:attribute name="UnitCost" type="moneyType" use="required"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
  <xs:simpleType name="ReferenceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="18"/>
      <xs:maxLength value="30"/>
    </xs:restriction>
  </xs:simpleType>

. . .

  <xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
    <xs:all>
      <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
      <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
      <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
    </xs:all>
  </xs:complexType>
  <xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
    <xs:sequence>
      <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
      <xs:choice>
        <xs:element name="address" type="AddressType" minOccurs="0"/>
        <xs:element name="fullAddress" type="FullAddressType" minOccurs="0"
                  xdb:SQLName="SHIP_TO_ADDRESS"/>
      </xs:choice>
      <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
    </xs:sequence>
  </xs:complexType>

. . .
```

```
  <xs:simpleType name="NameType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="20"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="FullAddressType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>

. . .

  <xs:simpleType name="DescriptionType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:complexType name="AddressType" xdb:SQLType="ADDRESS_T">
    <xs:sequence>
      <xs:element name="StreetLine1" type="StreetType"/>
      <xs:element name="StreetLine2" type="StreetType" minOccurs="0"/>
      <xs:element name="City" type="CityType"/>
      <xs:choice>
        <xs:sequence>
          <xs:element name="State" type="StateType"/>
          <xs:element name="ZipCode" type="ZipCodeType"/>
        </xs:sequence>
        <xs:sequence>
          <xs:element name="Province" type="ProvinceType"/>
          <xs:element name="PostCode" type="PostCodeType"/>
        </xs:sequence>
        <xs:sequence>
          <xs:element name="County" type="CountyType"/>
          <xs:element name="Postcode" type="PostCodeType"/>
        </xs:sequence>
      </xs:choice>
      <xs:element name="Country" type="CountryType"/>
    </xs:sequence>
  </xs:complexType>
  <xs:simpleType name="StreetType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="128"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CityType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="64"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="StateType">
    <xs:restriction base="xs:string">
      <xs:minLength value="2"/>
      <xs:maxLength value="2"/>
      <xs:enumeration value="AK"/>
      <xs:enumeration value="AL"/>
      <xs:enumeration value="AR"/>

 . . . -- A value for each US state abbreviation

      <xs:enumeration value="WY"/>
```

```
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ZipCodeType">
    <xs:restriction base="xs:string">
      <xs:pattern value="\d{5}"/>
      <xs:pattern value="\d{5}-\d{4}"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CountryType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="64"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CountyType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="32"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="PostCodeType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="12"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ProvinceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="2"/>
      <xs:maxLength value="2"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="NotesType">
    <xs:restriction base="xs:string">
      <xs:maxLength value="32767"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="UPCCodeType">
    <xs:restriction base="xs:string">
      <xs:minLength value="11"/>
      <xs:maxLength value="14"/>
      <xs:pattern value="\d{11}"/>
      <xs:pattern value="\d{12}"/>
      <xs:pattern value="\d{13}"/>
      <xs:pattern value="\d{14}"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

COPYEVOLVE Parameters and Errors

This is the signature of procedure `DBMS_XMLSCHEMA.copyEvolve`:

```
procedure copyEvolve(schemaURLs       IN XDB$STRING_LIST_T,
                     newSchemas       IN XMLSequenceType,
                     transforms       IN XMLSequenceType := NULL,
                     preserveOldDocs  IN BOOLEAN := FALSE,
                     mapTabName       IN VARCHAR2 := NULL,
                     generateTables   IN BOOLEAN := TRUE,
                     force            IN BOOLEAN := FALSE,
                     schemaOwners     IN XDB$STRING_LIST_T := NULL
                     parallelDegree   IN PLS_INTEGER := 0,
                     options          IN PLS_INTEGER := 0);
```

Table 20–1 describes the individual parameters. Table 20–2 describes the errors associated with the procedure.

Table 20–1 Parameters of Procedure DBMS_XMLSCHEMA.COPYEVOLVE

Parameter	Description
schemaURLs	Varray of URLs of XML schemas to be evolved (varray of VARCHAR2(4000). This should include the dependent schemas as well. Unless the force parameter is TRUE, the URLs should be in the dependency order, that is, if URL A comes before URL B in the varray, then schema A should not be dependent on schema B but schema B may be dependent on schema A.
newSchemas	Varray of new XML schema documents (XMLType instances). Specify this in exactly the same order as the corresponding URLs. If no change is necessary in an XML schema, provide the unchanged schema.
transforms	Varray of XSL documents (XMLType instances) that are applied to XML schema based documents to make them conform to the new schemas. Specify these in exactly the same order as the corresponding URLs. If no transformations are required, this parameter need not be specified.
preserveOldDocs	If this is TRUE, then the temporary tables holding old data are not dropped at the end of schema evolution. See also "Guidelines for Using Procedure COPYEVOLVE".
mapTabName	Specifies the name of table that maps old XMLType table or column names to names of corresponding temporary tables.
generateTables	By default this parameter is TRUE. If FALSE then XMLType tables or columns are not generated after registering new XML schemas. If FALSE, preserveOldDocs must be TRUE and mapTabName must not be NULL.
force	If this is TRUE, then errors during the registration of new schemas are ignored. If there are circular dependencies among the schemas, set this flag to TRUE to ensure that each schema is stored even though there may be errors in registration.
schemaOwners	Varray of names of schema owners. Specify these in exactly the same order as the corresponding URLs.
parallelDegree	Specifies the degree of parallelism to be used in a PARALLEL hint during the data-copy stage. If this is 0 (default value), a PARALLEL hint is absent from the data-copy statements.
options	Miscellaneous options. The only option is COPYEVOLVE_BINARY_XML, which means to register the new XML schemas for binary XML data and create the new tables or columns with binary XML as the storage model.

Table 20–2 Errors Associated with Procedure DBMS_XMLSCHEMA.COPYEVOLVE

Error Number and Message	Cause	Action
30942 XML Schema Evolution error for schema '<schema_url>' table "<owner_name>.<table_name>" column '<column_name>'	The given XMLType table or column that conforms to the given XML schema had errors during evolution. In the case of a table, the column name is empty. See also the more specific error that follows this.	Based on the schema, table, and column information in this error and the more specific error that follows, take corrective action.

*Table 20–2 (Cont.) Errors Associated with Procedure DBMS_*

Error Number and Message	Cause	Action
30943 XML Schema '<schema_url>' is dependent on XML schema '<schema_url>'	Not all dependent XML schemas were specified or the schemas were not specified in dependency order, that is, if schema S1 is dependent on schema S, S must appear before S1.	Include the previously unspecified schema in the list of schemas or correct the order in which the schemas are specified. Then retry the operation.
30944 Error during rollback for XML schema '<schema_url>' table "<owner_name>.<table_name>" column '<column_name>'	The given `XMLType` table or column that conforms to the given XML schema had errors during a rollback of XML schema evolution. For a table, the column name is empty. See also the more specific error that follows this.	Based on the schema, table, and column information in this error and the more specific error that follows, take corrective action.
30945 Could not create mapping table '<table_name>'	A mapping table could not be created during XML schema evolution. See also the more specific error that follows this.	Ensure that a table with the given name does not exist and retry the operation.
30946 XML Schema Evolution warning: temporary tables not cleaned up	An error occurred after the schema was evolved while cleaning up temporary tables. The schema evolution was successful.	If you need to remove the temporary tables, use the mapping table to get the temporary table names and drop them.

Limitations of Procedure COPYEVOLVE

Keep in mind the following limitations when you use procedure `DBMS_XMLSCHEMA.copyEvolve`:

- Indexes, triggers, constraints, row-level security (RLS) policies, and other metadata related to the `XMLType` tables that are dependent on the schemas are not preserved. These must be re-created after evolution.
- If top-level element names are changed, additional steps are required after `copyEvolve` finishes executing. See "Top-Level Element Name Changes" on page 20-8.
- Copy-based evolution cannot be used if there is a table with an object-type column that has an `XMLType` attribute that is dependent on any of the schemas to be evolved. For example, consider this table:

```
CREATE TYPE t1 AS OBJECT (n NUMBER, x XMLType);
CREATE TABLE tab1 (e NUMBER, o t1) XMLType
 COLUMN o.x XMLSchema "s1.xsd" ELEMENT "Employee";
```

  This assumes that an XML schema with a top-level element `Employee` has been registered under URL `s1.xsd`. It is not possible to evolve this XML schema, because table `tab1` with column `o` with `XMLType` attribute `x` is dependent on the XML schema. Note that although `copyEvolve` does not handle `XMLType` object attributes, it does raise an error in such cases.

Guidelines for Using Procedure COPYEVOLVE

The following general guideline applies to using procedure `DBMS_XMLSCHEMA.copyEvolve`. The rest of this section describes specific guidelines that can also be appropriate in particular contexts.

1. Turn off the recycle bin, to prevent dropped tables from being copied to it:

   ```
   ALTER SESSION SET RECYCLEBIN=off;
   ```

2. Identify the XML schemas that are dependent on the XML schema that is to be evolved. You can acquire the URLs of the dependent XML schemas using the following query, where *`schema_to_be_evolved`* is the schema to be evolved, and *`owner_of_schema_to_be_evolved`* is its owner (database user).

   ```
   SELECT dxs.SCHEMA_URL, dxs.OWNER
       FROM DBA_DEPENDENCIES dd, DBA_XML_SCHEMAS dxs
       WHERE dd.REFERENCED_NAME = (SELECT INT_OBJNAME
                                     FROM DBA_XML_SCHEMAS
                                     WHERE SCHEMA_URL = schema_to_be_evolved
                                       AND OWNER = owner_of_schema_to_be_evolved)
         AND dxs.INT_OBJNAME = dd.NAME;
   ```

   In many cases, no changes are needed in the dependent XML schemas. But if the dependent XML schemas need to be changed, then you must also prepare new versions of those XML schemas.

3. If the existing instance documents do not conform to the new XML schema, then you must provide an XSL stylesheet that, when applied to an instance document, transforms it to conform to the new schema. You must do this for each XML schema identified in Step 2. The transformation must handle documents that conform to all top-level elements in the new XML schema.

4. Call procedure `DBMS_XMLSCHEMA.copyEvolve`, specifying the XML schema URLs, new schemas, and transformation stylesheet.

Top-Level Element Name Changes

Procedure `DBMS_XMLSCHEMA.copyEvolve` assumes that top-level elements have not been dropped and that their names have not been changed in the new XML schemas. If there are such changes in your new XML schemas, then you can call procedure `copyEvolve` with parameter `generateTables` set to `FALSE` and parameter `preserveOldDocs` set to `TRUE`. In this way, new tables are not generated, and the temporary tables holding the old documents (backup copies) are not dropped at the end of the procedure. You can then store the old documents in whatever form is appropriate and drop the temporary tables. See "COPYEVOLVE Parameters and Errors" on page 20-5 for more details on using these parameters.

User-Created Virtual Columns of Tables Other Than Default Tables

For tables that are not default tables, any virtual columns that you create are not re-created during copy-based evolution. If the columns are needed, then set parameter `preserveOldDocs` to `TRUE`, create the tables, and copy the old documents after procedure `copyEvolve` has finished.

Ensure that the XML Schema and Dependents Are Not Used by Concurrent Sessions

Ensure that the XML schema and its dependents are not used by any concurrent session during the XML schema evolution process. If other, concurrent sessions have

shared locks on this schema at the beginning of the evolution process, then procedure DBMS_XMLSCHEMA.copyEvolve waits for these sessions to release the locks so that it can acquire an exclusive lock. However, this lock is released immediately to allow the rest of the process to continue.

Rollback When Procedure DBMS_XMLSCHEMA.COPYEVOLVE Raises an Error

Procedure DBMS_XMLSCHEMA.copyEvolve either completely succeeds or raises an error, in which case it attempts to roll back as much of the operation as possible. Evolving an XML schema involves many database DDL statements. When an error occurs, compensating DDL statements are executed to undo the effect of all steps executed to that point. If the old tables or schemas have been dropped, they are re-created, but any table, column, and storage properties and any auxiliary structures (such as indexes, triggers, constraints, and RLS policies) associated with the tables and columns are lost.

Failed Rollback From Insufficient Privileges

In certain cases you cannot roll back the copy-based evolution operation. For example, if table creation fails due to reasons not related to the new XML schema, then there is no way to roll back. An example is failure due to insufficient privileges. The temporary tables are not deleted even if preserveOldDocs is FALSE, so the data can be recovered. If the mapTabName parameter is null, the mapping table name is XDB$MAPTAB followed by a sequence number. The exact table name can be found using a query such as the following:

```
SELECT TABLE_NAME FROM USER_TABLES WHERE TABLE_NAME LIKE 'XDB$MAPTAB%';
```

Privileges Needed for XML Schema Evolution

Copy-based XML schema evolution may involve dropping or creating data types. Hence, you need type-related privileges such as DROP TYPE, CREATE TYPE, and ALTER TYPE.

You need privileges to delete and register the XML schemas involved in the evolution. You need all privileges on XMLType tables that conform to the schemas being evolved. For XMLType columns, the ALTER TABLE privilege is needed on corresponding tables. If there are schema-based XMLType tables or columns in other database schemas, you need privileges such as the following:

- CREATE ANY TABLE
- CREATE ANY INDEX
- SELECT ANY TABLE
- READ ANY TABLE
- UPDATE ANY TABLE
- INSERT ANY TABLE
- DELETE ANY TABLE
- DROP ANY TABLE
- ALTER ANY TABLE
- DROP ANY INDEX

To avoid needing to grant all these privileges to the database- schema owner, Oracle recommends that a database administrator perform the evolution if there are XML schema-based XMLType table or columns belonging to other database schemas.

Updating Existing XML Instance Documents Using an XSLT Stylesheet

After you modify a registered XML schema, you must update any existing XML instance documents that use the XML schema. You do this by applying an XSLT stylesheet to each of the instance documents. The stylesheet represents the difference between the old and new XML schemas.

Example 20–2 shows an XSLT stylesheet, in file `evolvePurchaseOrder.xsl`, that transforms existing purchase-order documents that use the old XML schema, so they use the new XML schema instead.

Example 20–2 evolvePurchaseOrder.xsl: XSLT Stylesheet to Update Instance Documents

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet
  version="1.0"
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <xsl:output method="xml" encoding="UTF-8"/>
  <xsl:template match="/PurchaseOrder">
    <PurchaseOrder>
      <xsl:attribute name="xsi:noNamespaceSchemaLocation">
        http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd
      </xsl:attribute>
      <xsl:for-each select="Reference">
        <xsl:attribute name="Reference">
          <xsl:value-of select="."/>
        </xsl:attribute>
      </xsl:for-each>
      <xsl:variable name="V264_394" select="'2004-01-01T12:00:00.000000-08:00'"/>
      <xsl:attribute name="DateCreated">
        <xsl:value-of select="$V264_394"/>
      </xsl:attribute>
      <xsl:for-each select="Actions">
        <Actions>
          <xsl:for-each select="Action">
            <Action>
              <xsl:for-each select="User">
                <User>
                  <xsl:value-of select="."/>
                </User>
              </xsl:for-each>
              <xsl:for-each select="Date">
                <Date>
                  <xsl:value-of select="."/>
                </Date>
              </xsl:for-each>
            </Action>
          </xsl:for-each>
        </Actions>
      </xsl:for-each>
      <xsl:for-each select="Reject">
        <Reject>
          <xsl:for-each select="User">
            <User>
              <xsl:value-of select="."/>
            </User>
          </xsl:for-each>
          <xsl:for-each select="Date">
            <Date>
              <xsl:value-of select="."/>
            </Date>
          </xsl:for-each>
          <xsl:for-each select="Comments">
            <Comments>
```

```
        <xsl:value-of select="."/>
      </Comments>
    </xsl:for-each>
  </Reject>
</xsl:for-each>
<xsl:for-each select="Requestor">
  <Requestor>
    <xsl:value-of select="."/>
  </Requestor>
</xsl:for-each>
<xsl:for-each select="User">
  <User>
    <xsl:value-of select="."/>
  </User>
</xsl:for-each>
<xsl:for-each select="CostCenter">
  <CostCenter>
    <xsl:value-of select="."/>
  </CostCenter>
</xsl:for-each>
<ShippingInstructions>
  <xsl:for-each select="ShippingInstructions">
    <xsl:for-each select="name">
      <name>
        <xsl:value-of select="."/>
      </name>
    </xsl:for-each>
  </xsl:for-each>
  <xsl:for-each select="ShippingInstructions">
    <xsl:for-each select="address">
      <fullAddress>
        <xsl:value-of select="."/>
      </fullAddress>
    </xsl:for-each>
  </xsl:for-each>
  <xsl:for-each select="ShippingInstructions">
    <xsl:for-each select="telephone">
      <telephone>
        <xsl:value-of select="."/>
      </telephone>
    </xsl:for-each>
  </xsl:for-each>
</ShippingInstructions>
<xsl:for-each select="SpecialInstructions">
  <SpecialInstructions>
    <xsl:value-of select="."/>
  </SpecialInstructions>
</xsl:for-each>
<xsl:for-each select="LineItems">
  <LineItems>
    <xsl:for-each select="LineItem">
      <xsl:variable name="V22" select="."/>
      <LineItem>
        <xsl:for-each select="@ItemNumber">
          <xsl:attribute name="ItemNumber">
            <xsl:value-of select="."/>
          </xsl:attribute>
        </xsl:for-each>
        <xsl:for-each select="$V22/Part">
          <xsl:variable name="V24" select="."/>
          <xsl:for-each select="@Id">
            <Part>
              <xsl:for-each select="$V22/Description">
                <xsl:attribute name="Description">
                  <xsl:value-of select="."/>
                </xsl:attribute>
```

```
                </xsl:for-each>
                <xsl:for-each select="$V24/@UnitPrice">
                  <xsl:attribute name="UnitCost">
                    <xsl:value-of select="."/>
                  </xsl:attribute>
                </xsl:for-each>
                <xsl:value-of select="."/>
              </Part>
            </xsl:for-each>
          </xsl:for-each>
          <xsl:for-each select="$V22/Part">
            <xsl:for-each select="@Quantity">
              <Quantity>
                <xsl:value-of select="."/>
              </Quantity>
            </xsl:for-each>
          </xsl:for-each>
        </LineItem>
      </xsl:for-each>
    </LineItems>
  </xsl:for-each>
 </PurchaseOrder>
</xsl:template>
</xsl:stylesheet>
```

Examples of Using Procedure COPYEVOLVE

Example 20–3 loads a revised XML schema and evolution XSL stylesheet into Oracle XML DB Repository.

Example 20–3 Loading Revised XML Schema and XSLT Stylesheet

```
DECLARE
  res BOOLEAN;
BEGIN
  res := DBMS_XDB_REPOS.createResource(         -- Load revised XML schema
           '/source/schemas/poSource/revisedPurchaseOrder.xsd',
           bfilename('XMLDIR', 'revisedPurchaseOrder.xsd'),
           nls_charset_id('AL32UTF8'));
  res := DBMS_XDB_REPOS.createResource(         -- Load revised XSL stylesheet
           '/source/schemas/poSource/evolvePurchaseOrder.xsl',
           bfilename('XMLDIR', 'evolvePurchaseOrder.xsl'),
           nls_charset_id('AL32UTF8'));
END;
/
```

Example 20–4 shows how to use procedure `DBMS_XMLSCHEMA.copyEvolve` to evolve the XML schema `purchaseOrder.xsd` to `revisedPurchaseOrder.xsd` using the XSLT stylesheet `evolvePurchaseOrder.xsl`.

Example 20–4 Updating an XML Schema Using DBMS_XMLSCHEMA.COPYEVOLVE

```
BEGIN
  DBMS_XMLSCHEMA.copyEvolve(
    xdb$string_list_t('http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd'),
    XMLSequenceType(XDBURIType('/source/schemas/poSource/revisedPurchaseOrder.xsd').getXML()),
    XMLSequenceType(XDBURIType('/source/schemas/poSource/evolvePurchaseOrder.xsl').getXML()));
END;

SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[1]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) line_item
  FROM purchaseorder po
```

```
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2003030912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

LINE_ITEM
--------------------------------------------------------------------------------
<LineItem ItemNumber="1">
  <Part Description="A Night to Remember" UnitCost="39.95">715515009058</Part>
  <Quantity>2</Quantity>
</LineItem>
```

The same query would have produced the following result before the schema evolution:

```
LINE_ITEM
------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>A Night to Remember</Description>
  <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
</LineItem>
```

Procedure `DBMS_XMLSCHEMA.copyEvolve` evolves registered XML schemas in such a way that existing instance documents continue to remain valid.

> **Caution:** Before executing procedure `DBMS_XMLSCHEMA.copyEvolve`, always *back up* all registered XML schemas and all XML documents that conform to them. Procedure `copyEvolve` *deletes* all documents that conform to registered XML schemas.

First, procedure `copyEvolve` copies the data in XML schema-based `XMLType` tables and columns to temporary tables. It then drops the original tables and columns, and deletes the old XML schemas. After registering the new XML schemas, it creates `XMLType` tables and columns and populates them with data (unless parameter `GENTABLES` is `FALSE`) but it does not create any auxiliary structures such as indexes, constraints, triggers, and row-level security (RLS) policies. Procedure `copyEvolve` creates the tables and columns as follows:

- It creates default tables while registering the new schemas.
- It creates tables that are not default tables using a statement of the following form:

  ```
  CREATE TABLE table_name OF XMLType OID 'oid'
     XMLSCHEMA schema_url ELEMENT element_name
  ```

  where *`OID`* is the original OID of the table, before it was dropped.
- It adds `XMLType` columns using a statement of the following form:

  ```
  ALTER TABLE table_name ADD (column_name XMLType) XMLType COLUMN
   column_name XMLSCHEMA schema_url ELEMENT element_name
  ```

When a new XML schema is registered, types are generated if the registration of the corresponding old schema had generated types. If an XML schema was global before the evolution, then it is also global after the evolution. Similarly, if an XML schema was local before the evolution, then it is also local (owned by the same user) after the evolution.

You have the option to preserve the temporary tables that contain the old documents, by setting parameter `preserveOldDocs` to `TRUE`. All temporary tables are created in the

database schema of the current user. For XMLType tables, the temporary table has the columns shown in Table 20–3.

Table 20–3 XML Schema Evolution: XMLType Table Temporary Table Columns

Name	Type	Comment
Data	CLOB	XML document from the old table, in CLOB format.
OID	RAW(16)	OID of the corresponding row in the old table.
ACLOID	RAW(16)	This column is present only if the old table is hierarchy-enabled. ACLOID of corresponding row in old table.
OWNERID	RAW(16)	This column is present only if old table is hierarchy-enabled. OWNERID of corresponding row in old table.

For XMLType columns, the temporary table has the columns shown in Table 20–4.

Table 20–4 XML Schema Evolution: XMLType Column Temporary Table Columns

Name	Type	Comment
Data	CLOB	XML document from the old column, in CLOB format.
RID	ROWID	ROWID of the corresponding row in the table containing this column.

Procedure copyEvolve stores information about the mapping from the old table or column name to the corresponding temporary table name in a separate table specified by parameter mapTabName. If preserveOldDocs is TRUE, then the mapTabName parameter must not be NULL, and it must not be the name of any existing table in the current database schema. Each row in the mapping table has information about one of the old tables/columns. Table 20–5 shows the mapping table columns.

Table 20–5 Procedure COPYEVOLVE Mapping Table

Column Name	Column Type	Comment
SCHEMA_URL	VARCHAR2(700)	URL of the schema to which this table or column conforms.
SCHEMA_OWNER	VARCHAR2(30)	Owner of the schema.
ELEMENT_NAME	VARCHAR2(256)	Element to which this table or column conforms.
TABLE_NAME	VARCHAR2(65)	Qualified name of the table (<owner_name>.<table_name>).
TABLE_OID	RAW(16)	OID of table.
COLUMN_NAME	VARCHAR2(4000)	Name of the column (NULL for XMLType tables).
TEMP_TABNAME	VARCHAR2(30)	Name of temporary table that holds the data for this table or column.

You can avoid generating any tables or columns after registering the new XML schema by setting parameter GENTABLES to FALSE. If GENTABLES is FALSE, parameter PRESERVEOLDDOCS must be TRUE and parameter MAPTABNAME must not be NULL. This

ensures that the data in the old tables is not lost. This is useful if you do not want the tables to be created by the procedure, as described in section "COPYEVOLVE Parameters and Errors" on page 20-5.

By default, it is assumed that all XML schemas are owned by the current user. If this is not true, then you must specify the owner of each XML schema in the `schemaOwners` parameter.

> **See Also:** *Oracle Database SQL Language Reference* for the complete description of `ALTER TABLE`

In-Place XML Schema Evolution

In-place XML schema evolution makes changes to an XML schema without requiring that existing data be copied, deleted, and reinserted. In-place evolution is thus much faster than copy-based evolution. However, in-place evolution also has several restrictions that do not apply to copy-based evolution.

You use procedure `DBMS_XMLSCHEMA.inPlaceEvolve` to perform in-place evolution. Using this procedure, you identify the changes to be made to an existing XML schema by specifying an XML schema-differences document, and you optionally specify flags to be applied to the evolution process.

In-place evolution constructs a new version of an XML schema by applying changes specified in a `diffXML` document, validates that new XML schema (against the XML schema for XML schemas), constructs DDL statements to evolve the disk structures used to store the XML instance documents associated with the XML schema, executes these DDL statements, and replaces the old version of the XML schema with the new, in that order. If the new version of the XML schema is not a valid schema, then in-place evolution fails.

Restrictions for In-Place XML Schema Evolution

Because in-place XML schema evolution avoids copying data, it does not permit arbitrary changes to an XML schema. This section describes why certain changes are not permitted. For the list of changes supported by in-place evolution, see "Supported Operations for In-Place XML Schema Evolution" on page 20-17.

The primary restriction on using in-place evolution can be stated generally as a requirement that a given XML schema can be evolved in place in only a backward-compatible way. **Backward-compatible** here means that any possible instance document that would validate against a given XML schema must also validate against a later (evolved) version of that XML schema.

This applies to *all possible* conforming instance documents, not only to *existing* instance documents For XML data that is stored as binary XML, backward compatibility also means that any XML schema annotations that affect binary XML treatment must not change during evolution. Backward compatibility is described in section "Backward-Compatibility Restrictions" on page 20-15.

In addition to this general backward-compatibility restriction, there are some other restrictions for in-place evolution. These are described in section "Other Restrictions on In-Place Evolution" on page 20-17.

Backward-Compatibility Restrictions

The restrictions described in this section ensure backward compatibility of an evolved XML schema, so that any possible instance documents that satisfy the old XML schema also satisfy the new schema.

Changes in Data Layout on Disk Certain changes to an XML schema alter the layout of the associated instance documents on disk, and are therefore not permitted. This situation is more common when the storage layer is tightly integrated with information derived from the XML schema, as is the case for object-relational storage.

One such example is an XML schema, registered for object-relational storage mapping, that is evolved by splitting a complex type into two complex types. In Example 20–5, complex type `ShippingInstructionsType` is split into two complex types, `Person-Name` and `Contact-Info`, and the `ShippingInstructionsType` complex type is deleted.

Example 20–5 Splitting a Complex Type into Two Complex Types

These code excerpts show the definitions of the original `ShippingInstructionsType` type and the new `Person-Name` and `Contact-Info` types.

```
<complexType name="ShippingInstructionsType">
    <sequence>
        <element name="name"   type="NameType" minOccurs="0"/>
        <element name="address" type="AddressType" minOccurs="0"/>
        <element name="telephone" type="TelephoneType" minOccurs="0"/>
    </sequence>
</complexType>

<complexType name="Person-Name">
    <sequence>
        <element name="name" type="NameType" minOccurs="0"/>
    </sequence>
</complexType>

<complexType name="Contact-Info">
    <sequence>
        <element name="address" type="AddressType" minOccurs="0"/>
        <element name="telephone" type="TelephoneType" minOccurs="0"/>
    </sequence>
</complexType>
```

Even if this XML schema has no associated instance documents, and therefore no data copy is required, a change in the layout of existing tables is required to accommodate future instance documents.

Reordering of XML Schema Constructs You cannot use in-place evolution to reorder schema elements in a way that affects the DOM fidelity of instance documents. For example, you cannot change the order of elements within a `<sequence>` element in a complex type definition. As an example, if a complex type named `ShippingInstructionsType` requires that its child elements `name`, `address`, and `telephone` be in that order, you cannot use in-place evolution to change the order to `name`, `telephone`, and `address`.

Changes from a Collection to a Non-Collection You cannot use in-place evolution to change a collection to a non-collection. An example would be changing from a `maxOccurs` value greater than one to a `maxOccurs` value of one. You cannot use in-place evolution to delete an element from a complex type if the deletion requires that a collection be evolved to a non-collection.

Model Changes within a complexType Element A **model** is one of the following elements: `group`, `choice`, `sequence`, or `all`. Within a `complexType` element you cannot use in-place evolution to either add a new model or replace an existing model with a

model of another type (for example, replace a `choice` element with a `sequence` element). You can, however, add a global `group` element, that is, add a `group` element outside of a `complexType` element.

Other Restrictions on In-Place Evolution

The restrictions on in-place XML schema evolution that are described in this section are necessary for reasons other than backward compatibility of the evolved XML schema.

Changes to Attributes in Namespace xdb Except for attribute `xdb:defaultTable`, you cannot use in-place evolution to modify any attributes in namespace `http://xmlns.oracle.com/xdb` (which has the predefined prefix `xdb`).

Changes from a Non-Collection to a Collection When XML data is stored object-relationally, you cannot use in-place evolution to change a non-collection object type to a collection object type. An example would be adding an element to a complex type with the element name matching the name of an element already present in the type (or in another type that is related to the first type through inheritance).

Supported Operations for In-Place XML Schema Evolution

This section describes operations that are supported for in-place schema evolution. This list of supported operations is not necessarily exhaustive. Some of the operations listed here are not permitted in specific contexts, which are specified.

- Add an optional element to a complex type or group: Always permitted. An example is the addition of the optional element `shipmethod` in the following complex type definition:

```
<xs:complexType name="ShippingInstructionsType">
    <xs:sequence>
        <xs:element name="name" type="NameType" minOccurs="0"/>
        <xs:element name="address" type="AddressType" minOccurs="0"/>
        <xs:element name="telephone" type="TelephoneType" minOccurs="0"/>
        <xs:element name = "shipmethod" type = "xs:string" minOccurs = "0"/>
    </xs:sequence>
</xs:complexType>
```

- Add an optional attribute to a complex type or attribute group: Always permitted. An example is the addition of the optional attribute `shipbydate` in the following complex type definition:

```
<xs:complexType name="ShippingInstructionsType">
    <xs:sequence>
        <xs:element name="name" type="NameType" minOccurs="0"/>
        <xs:element name="address" type="AddressType" minOccurs="0"/>
        <xs:element name="telephone" type="TelephoneType" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="shipbydate" type="DateType" use="optional"/>
</xs:complexType>
```

- Convert an element from simple type to complex type with simple content: Supported only if the storage model is binary XML.
- Modify the value attribute of an existing maxLength element: Always permitted. The value can only be increased, not decreased.
- Add an enumeration value: You can add a new enumeration value only to the end of an enumeration list.

- Add a global element: Always permitted. An example is the addition of the global element `PurchaseOrderComment` in the following schema definition:

```
<xs:schema ...>
...
    <xs:element name="PurchaseOrderComment" type="string" xdb:defaultTable=""/>
..
</xs:schema>
```

- Add a global attribute: Always permitted.
- Add or delete a global complex type: Always permitted. An example is the addition of the global complex type `ComplexAddressType` in the following schema definition:

```
<xs:schema ...>
....
    <xs:complexType name="ComplexAddressType">
        <xs:sequence>
            <xs:element name="street" type="string"/>
            <xs:element name="city" type="string"/>
            <xs:element ref="zip" type="positiveInteger"/>
            <xs:element name="country"  type="string"/>
        </xs:sequence>
     </xs:complexType>
...
</xs:schema>
```

- Add or delete a global simple type: Always permitted.
- Change the `minOccurs` attribute value: The value of `minOccurs` can only be decreased.
- Change the `maxOccurs` attribute value: The value of `maxOccurs` can only be increased, and this is only possible for data stored as binary XML. That is, you cannot make any change to the `maxOccurs` attribute for data stored object-relationally.
- Add or delete a global group or `attributeGroup`: Always permitted. An example is the addition of an `Instructions` group in the following type definition:

```
<xsd:schema ...>
...
  <xsd:group name="Instructions">
    <xsd:sequence>
     <xsd:element name="ShippingInstructions" type="ShippingInstructionsType"/>
      <xsd:element name="SpecialInstructions" type=" SpecialInstructionsType"/>
    </xsd:sequence>
  </xsd:group>
...
</xsd:schema>
```

- Change the xdb:defaultTable attribute value: Always permitted. Changes are *not* permitted to any other attributes in the `xdb` namespace.
- Add, modify, or delete a comment or processing instruction: Always permitted.

Guidelines for Using In-Place XML Schema Evolution

The following guidelines apply to in-place XML-schema evolution:

- *Before* you perform an in-place XML-schema evolution:

- *Back up all existing data* (instance documents) for the XML schema to be evolved.

  Caution: Make sure that you back up your data before performing in-place XML schema evolution, in case the result is not what you intended. There is *no rollback* possible after an in-place evolution. If any errors occur during evolution, or if you make a major mistake and need to redo the entire operation, you must be able to go back to the backup copy of your original data.

- *Perform a dry run* using trace only, that is, without actually evolving the XML schema or updating any instance documents, produce a trace of the update operations that would be performed during evolution. To do this, set the `flag` parameter value to only `INPLACE_TRACE`. Do not also use `INPLACE_EVOLVE`.

  After performing the dry run, examine the trace file, verifying that the listed DDL operations are in fact those that you intend.

- *After* you perform an in-place XML-schema evolution:

  If you are accessing the database using a client that caches data, or if you are not sure whether this is the case, then *restart your client*. Otherwise, the pre-evolution version of the XML schema might continue to be used locally, with unpredictable results.

  See Also: *Oracle Database Administrator's Guide* for information about using trace files

inPlaceEvolve Parameters

This is the signature of procedure `DBMS_XMLSCHEMA.inPlaceEvolve`:

```
procedure inPlaceEvolve(schemaURL IN VARCHAR2,
                        diffXML   IN XMLType,
                        flags     IN NUMBER);
```

Table 20–6 describes the individual parameters.

Table 20–6 Parameters of Procedure DBMS_XMLSCHEMA.INPLACEEVOLVE

Parameter	Description
`schemaURL`	URL of the XML schema to be evolved (`VARCHAR2`).
`diffXML`	XML document (`XMLType` instance) that conforms to the `xdiff` XML schema, and that specifies the changes to apply and the locations in the XML schema where the changes are to be applied. For information about how to create the document for this parameter, see "The diffXML Parameter Document" on page 20-20.

Table 20–6 (Cont.) Parameters of Procedure DBMS_XMLSCHEMA.INPLACEEVOLVE

Parameter	Description
flags	A bit mask that controls the behavior of the procedure. You can set the following bit values in this mask independently, summing them to define the overall effect. The default flags value is 1 (bit 1 on, bit 2 off), meaning that in-place evolution is performed and no trace is written. ■ INPLACE_EVOLVE (value 1, meaning that bit 1 is on) – Perform in-place XML schema evolution. Construct a new XML schema and validate it (against the XML schema for XML schemas). Construct the DDL statements needed to evolve the instance-document disk structures. Execute the DDL statements. Replace the old XML schema with the new. ■ INPLACE_TRACE (value 2, meaning that bit 2 is on) – Perform all steps necessary for in-place evolution, *except* executing the DDL statements and overwriting the old XML schema with the new, then write both the DDL statements and the new XML schema to a trace file. That is, each of the bits constructs the new XML schema, validates it, and determines the steps needed to evolve the disk structures underlying the instance documents. In addition: ■ Bit INPLACE_EVOLVE carries out those evolution steps and replaces the old XML schema with the new. ■ Bit INPLACE_TRACE saves the evolution steps and the new XML schema in a trace file (it does not carry out the evolution steps).

Procedure DBMS_XMLSCHEMA.inPlaceEvolve raises an error in the following cases:

- An XPath expression is invalid, or is syntactically correct but does not target a node in the XML schema.
- The diffXML document does not conform to the xdiff XML schema.
- The change makes the XML schema invalid or not well formed.
- A generated DDL statement (CREATE TYPE, ALTER TYPE, and so on) causes a problem when it is executed.
- An index object associated with an XMLType table is in an unsafe state, which could be caused by partition management operations.

The diffXML Parameter Document

The value of the diffXML parameter to procedure DBMS_XMLSCHEMA.inPlaceEvolve is an XML document (as an XMLType instance) that specifies the changes to be applied to an XML schema for in-place evolution. This diffXML document contains a sequence of operations that describe the changes between the old XML schema and the new (the intended evolution result). The changes specified by the diffXML document are applied in order.

You must create the XML document to be used for the diffXML parameter You can do this in any of the following ways:

- The XMLDiff JavaBean (oracle.xml.differ.XMLDiff)
- The xmldiff command-line utility
- SQL function XMLDiff

The diffXML parameter document must conform to the xdiff XML schema.

The rest of this section presents examples of some operations in a document that conforms to the xdiff XML schema.

See Also:

- "xdiff.xsd: XML Schema for Comparing Schemas for In-Place Evolution" on page A-29
- *Oracle XML Developer's Kit Programmer's Guide* for information on using the `XMLDiff` JavaBean
- *Oracle XML Developer's Kit Programmer's Guide* for information on command-line utility `xmldiff`
- *Oracle Database SQL Language Reference* for information on SQL function `XMLDiff`

diffXML Operations and Examples

This section describes some operations that can be specified in the document for the `diffXML` document supplied to procedure `DBMS_XMLSCHEMA.inPlaceEvolve`. It presents an example XML document that conforms to the `xdiff` XML schema.

The `<append-node>` element is used for most of the supported changes, such as adding a new attribute to a complex type or appending a new element to a group.

The `<insert-node-before>` element specifies that a node of the given type should be inserted before the specified node. The `xpath` attribute specifies the location of the specified node and the `node-type` attribute specifies the type of node to be inserted. The node to be inserted is specified by the `<content>` child element. The `<insert-node-before>` element is mainly used for inserting comments and processing instructions, and for changing and adding add annotation elements.

The `<delete-node>` element specifies that the node with the given XPath (specified by the `xpath` attribute) should be deleted along with all its children. For example, you can use this element to delete comments and annotation elements. You can also use this element, in conjunction with `<append-node>` or `<insert-node-before>`, to make changes to an existing node.

Example 20–6 shows an XML document for the `diffXML` parameter that specifies the following changes:

- Delete complex type `PartType`.
- Add complex type `PartType` with a maximum length of 28.
- Add a comment before element `ShippingInstructions`.
- Add a required element `shipmethod` to element `ShippingInstructions`.

Example 20–6 diffXML Parameter Document

```
<xd:xdiff  xmlns="http://www.w3c.org/2001/XMLSchema"
           xmlns:xd="http://xmlns.oracle.com/xdb/xdiff.xsd"
           xmlns:xsi="http://www.w3c.org/2001/XMLSchema-Instance"
           xsi:schemaLocation="http://xmlns.oracle.com/xdb/xdiff.xsd
           http://xmlns.oracle.com/xdb/xdiff.xsd">
 <xd:delete-node xpath="/schema/complexType[@name=&quote;PartType&quote;]//maxLength/>
 <xd:append-node
  parent-xpath = "/schema/complexType[@name=&quote;PartType&quote;]//restriction"
  node-type = "element">
  <xd:content>
    <xs:maxLength value = "28"/>
  </xd:content>
 </xd:append-node>
 <xd:insert-node-before
```

```
  xpath="/schema/complexType[@name =&quote;ShippingInstructionsType&quote;]/sequence"
  node-type="comment">
  <xd:content>
    <!-- A type representing instructions for shipping -->
  </xd:content>
 </xd:insert-node-before>
 <xd:append-node
  parent-xpath="/schema/complexType[@name=&quote;ShippingInstructionsType&quote;]/sequence"
  node-type="element">
  <xd:content>
   <xs:element name = "shipmethod" type = "xs:string" minOccurs = "1"/>
  </xd:content>
 </xd:append-node>
</xd:xdiff>
```

Part VI

Oracle XML DB Repository

Part VI of this manual describes Oracle XML DB repository. It includes how to version your data, implement and manage security, and how to use the associated Oracle XML DB APIs to access and manipulate repository data.

Part V contains the following chapters:

21

Accessing Oracle XML DB Repository Data

This chapter describes how to access data in Oracle XML DB Repository using standard protocols such as FTP and HTTP(S)/WebDAV, and other Oracle XML DB resource Application Program Interfaces (APIs). It also introduces you to using `RESOURCE_VIEW` and `PATH_VIEW` as the SQL mechanism for accessing and manipulating repository data. It includes a table for comparing repository operations through the various resource APIs.

This chapter contains these topics:

Overview of Oracle XML DB Repository

Using Oracle XML DB Repository you can store content in the database in hierarchical structures, as opposed to traditional relational database structures. Although Oracle XML DB Repository can manage any kind of content, it provides specialized capabilities and optimizations related to managing resources where the content is XML.

Relational databases are traditionally poor at managing hierarchical structures and traversing a path or a URL. Oracle XML DB Repository provides you with a hierarchical organization of XML content in the database. You can query and manage it as if it were organized using files and folders.

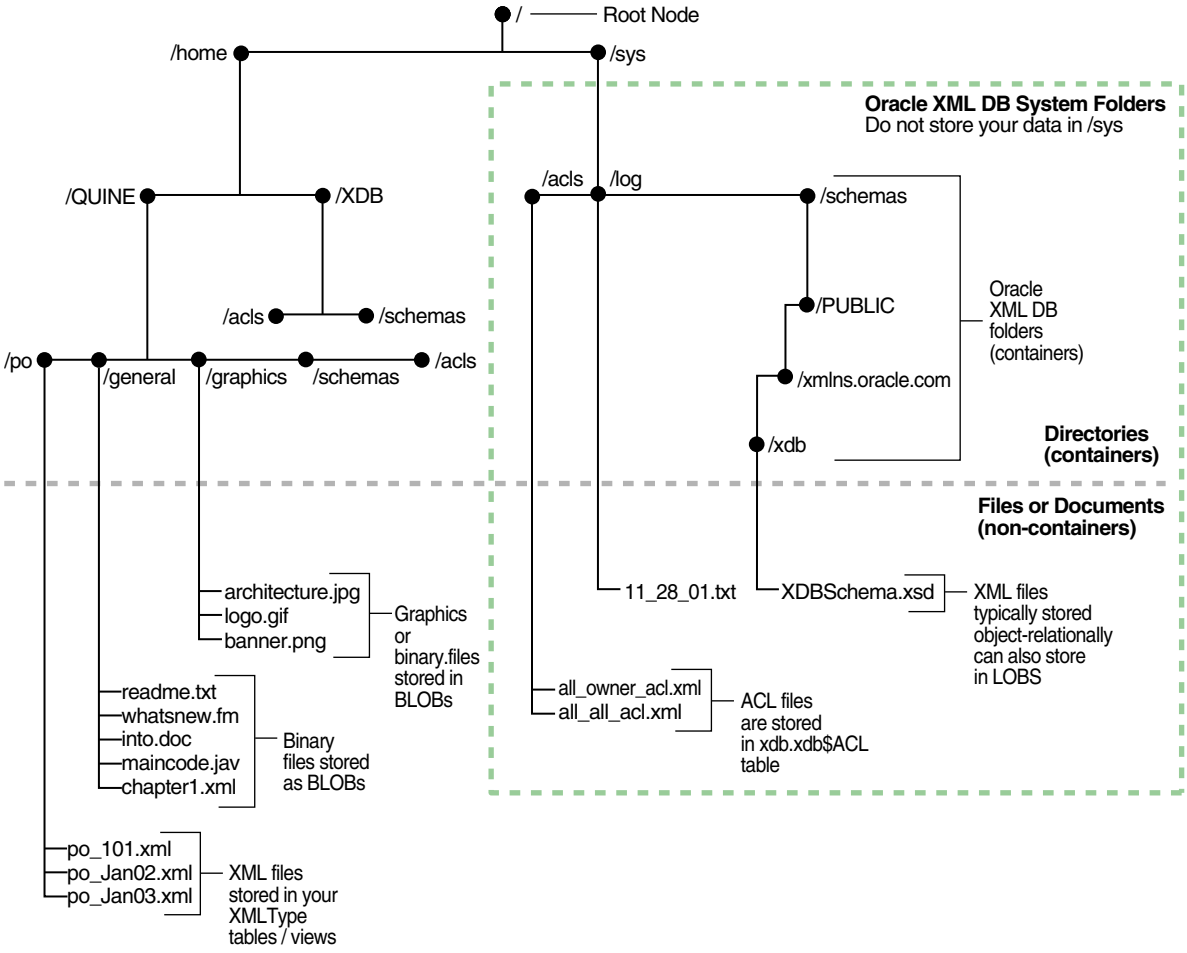
The relational table-row-column metaphor is an effective model for managing highly structured data. It can be less effective for managing semi-structured and unstructured data, such as document-oriented XML data.

For example, a book is not easily represented as a set of rows in a table. It might be more natural to represent a book as a hierarchy, book—chapter—section—paragraph, and to represent the hierarchy as a set of folders and subfolders.

A hierarchical repository index speeds up folder and path traversals. Oracle XML DB includes a patented hierarchical index that speeds up folder and path traversals in Oracle XML DB Repository. The hierarchical repository index is transparent to end users, and lets Oracle XML DB perform folder and path traversals at speeds comparable to or faster than conventional file systems.

Figure 21–1 is an example of a hierarchical structure that shows a typical tree of folders and files in Oracle XML DB Repository. The top of the tree shows `/`, the root folder.

Figure 21–1 A Folder Tree, Showing Hierarchical Structures in the Repository



Note: Folder `/sys` is used by Oracle XML DB to maintain *system-defined* XML schemas, access control lists (ACLs), and so on. Do *not* add or modify any data in folder `/sys`.

Your applications can access content in Oracle XML DB Repository using standard connect-access protocols such as FTP, HTTP(S), and WebDAV, in addition to languages SQL, PL/SQL, Java, and C. Oracle XML DB adds native support to Oracle Database for these protocols, which were designed for document-centric operations. By providing support for these protocols, Oracle XML DB lets Microsoft Windows

Explorer, Microsoft Office, and products from vendors such as Altova and Adobe work directly with XML content stored in the repository.

The repository gives you direct access to XML content stored in Oracle Database, as if it were stored in a file system. You can set access control privileges on repository files and folders.

These features are available because the repository is modeled on **WebDAV**, an IETF standard that defines a set of extensions to the HTTP protocol. WebDAV lets an HTTP server act as a file server for a DAV-enabled client. For example, a WebDAV-enabled editor can interact with an HTTP/WebDAV server as if it were a file system.

The WebDAV standard uses the term **resource** to describe a file or a folder. Each resource managed by a WebDAV server is identified by a URL. A resource has not only content but also associated metadata.

This chapter provides an overview of how to access data in Oracle XML DB Repository folders using the standard protocols. It discusses APIs that you can use to access the repository object hierarchy using Java, SQL, and PL/SQL.

See Also:

- Chapter 24, "Repository Access Using RESOURCE_VIEW and PATH_VIEW"
- Chapter 26, "PL/SQL Access to Oracle XML DB Repository"
- Chapter 27, "Repository Access Control"
- Chapter 28, "Repository Access Using Protocols"

Oracle XML DB Provides Name-Level Locking

When using a relational database to maintain hierarchical folder structures, ensuring a high degree of concurrency when adding and removing items in a folder is a challenge. In conventional file systems there is no concept of a transaction. Each operation (add a file, create a subfolder, rename a file, delete a file, and so on) is treated as an atomic transaction. Once the operation has completed the change is immediately available to all other users of the file system.

Note: As a consequence of transactional semantics enforced by the database, folders created using SQL statements are *not* visible to other database users until the transaction is committed. *Concurrent* access to Oracle XML DB Repository is controlled by the same mechanism used to control concurrency in Oracle Database. The integration of the repository with Oracle Database provides *strong management options for XML content*.

One key advantage of Oracle XML DB Repository is the ability to use SQL for repository operations in the context of a logical transaction. Applications can create long-running transactions that include updates to one or more folders. In this situation, a conventional locking strategy that takes an exclusive lock on each updated folder or directory tree would quickly result in significant concurrency problems.

Oracle XML DB solves this by providing for name-level locking rather than folder-level locking. Repository operations such as creating, renaming, moving, or deleting a sub-folder or file do not require that your operation be granted an exclusive write lock on the target folder. The repository manages concurrent folder operations

by locking the name within the folder rather than the folder itself. The name and the modification type are put on a queue.

Only when the transaction is committed is the folder locked and its contents modified. Hence Oracle XML DB lets multiple applications perform concurrent updates on the contents of a folder. The queue is also used to manage folder concurrency by preventing two applications from creating objects with the same name.

Queuing folder modifications until commit time also minimizes I/O when a number of changes are made to a single folder in the same transaction.

This is useful when several applications generate files quickly in the same directory, for example when generating trace or log files, or when maintaining a spool directory for printing or e-mail delivery.

Two Ways to Access Oracle XML DB Repository Resources

There are two ways to access Oracle XML DB Repository resources:

- Navigational or path-based access. This uses a hierarchical index of resources. Each resource has one or more unique path names that reflect its location in the hierarchy. You can navigate, using XPath expressions, to any repository resource.

  A repository resource can be created as a reference to an existing `XMLType` object in the database. You can navigate to any such database object using XPath. See "Navigational or Path Access to Repository Resources" on page 21-12.

- SQL access to the repository. This is done using special views that expose resource properties and path names, and map hierarchical access operators onto the Oracle XML DB schema. See "Query-Based Access to Repository Resources" on page 21-17.

See Also:

- "Oracle XML DB Repository Access" on page 2-5 for guidance on selecting an access method
- Table 21–3, " Accessing Oracle XML DB Repository: API Options" for a summary comparison of the access methods

A Uniform Resource Locator (URL) is used to access an Oracle XML DB resource. A URL includes the host name, protocol information, path name, and resource name of the object.

Database Schema (User Account) XDB and the Repository

Database schema (user account) `XDB` is created during Oracle XML DB installation. The primary table in this schema is an `XMLType` table called `XDB$RESOURCE`. This contains one row for each resource (file or folder) in Oracle XML DB Repository. Documents in this table are referred to as **resource documents**. The XML schema that defines the structure of an Oracle XML DB resource document is registered under URL, `"http://xmlns.oracle.com/xdb/XDBResource.xsd`. All of the *metadata* for managing the repository is stored in a database schema owned by user `XDB`.

The tables owned by database schema (user) `XDB` are *internal*. Oracle recommends the following:

- Create a *dedicated tablespace* for use only by user `XDB`, which means also for Oracle XML DB Repository. Ensure that the tablespace is *not* read-only.

- Do *not* directly manipulate any tables or data owned by user `XDB`. For example, do not compress or uncompress them.

  Use only the PL/SQL subprograms and database views provided by Oracle XML DB to carry out operations on any tables or data owned by user `XDB`.

- *Never unlock* user `XDB`, under any circumstance.

See Also:

- "Package DBMS_XDB_ADMIN" on page 35-13, for information about creating a dedicated tablespace for user `XDB` and the repository
- *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

Repository Terminology and Supplied Resources

Oracle XML DB Repository is the set of database objects, across all XML and database schemas, that are mapped to path names. It is a connected, directed, acyclic[1] graph of resources, with a single root node (`/`). Each resource in the graph has one or more associated path names: the repository supports multiple links to a given resource. The repository can be thought of as a file system of objects rather than files.

Repository Terminology

The following list describes terms used in Oracle XML DB Repository:

- **resource** – Any object or node in the repository hierarchy. A resource is identified by a Uniform Resource Locator (URL), which includes the path name and resource name of the object.

  See Also:

  - "Oracle XML DB Repository: Overview" on page 1-15
  - "Oracle XML DB Repository Resources" on page 21-7

- **folder** – A resource that can contain other resources. Sometimes called a **directory**.
- **path name** – A hierarchical name representing an absolute path to a resource. It is composed of a slash (`/`) representing the repository root, followed by zero or more **path components** separated by slashes. A path component cannot be only `.` or `..`, but a period (`.`) can otherwise be used in a path component. A path component is composed of any characters in the database character set *except* slash (`/`), backslash (`\`), and those characters specified in the Oracle XML DB configuration file, `xdbconfig.xml`, by configuration parameter `/xdbconfig/sysconfig/invalid-pathname-chars`.
- **resource name** (or **link name**) – The name of a resource within its parent folder. This is the rightmost path component of a path name. Resource names must be unique within their immediately containing folder, and they are case-sensitive.
- **resource content** – The body, or data, of a resource. This is what you get when you treat the resource as a file and ask for its content. This is always of type `XMLType`.

[1] The graph is established by the hard links that define the repository structure, and cycles are not permitted using hard links. You can, however, introduce cycles using weak links. See "Hard Links and Weak Links" on page 21-10.

- **XDBBinary element** – An XML element that contains binary data. It is defined by the Oracle XML DB XML schema. `XDBBinary` elements are stored in the repository whenever unstructured binary data is uploaded into Oracle XML DB.
- **access control list** (ACL) – An ordered list of rules that specify access privileges for principals (users or roles) to one or more repository resources.

  See Also: Chapter 27, "Repository Access Control"

Many terms used by Oracle XML DB have common synonyms in other contexts, as shown in Table 21–1.

Table 21–1 Synonyms for Oracle XML DB Repository Terms

Synonym	Repository Term	Usage
collection	folder	WebDAV
directory	folder	operating systems
privilege	privilege	permission
right	privilege	various
WebDAV folder	folder	Web folder
role	group	access control
revision	version	RCS, CVS
file system	repository	operating systems
hierarchy	repository	various
file	resource	operating systems
binding	link	WebDAV

Supplied Files and Folders

The list of supplied Oracle XML DB Repository files and folders is as follows. In addition to using these, you can create your own folders and files wherever you want.

```
/dbfs[2]
/public
/sys
/sys/acls
/sys/acls/all_all_acl.xml
/sys/acls/all_owner_acl.xml
/sys/acls/bootstrap_acl.xml
/sys/acls/ro_all_acl.xml
/sys/apps
/sys/asm
/sys/log
/sys/schemas
/sys/schemas/PUBLIC
/sys/schemas/PUBLIC/www.w3.org
/sys/schemas/PUBLIC/www.w3.org/2001
/sys/schemas/PUBLIC/www.w3.org/2001/xml.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResource.xsd
```

[2] Repository folder `/dbfs` gives you protocol access to your DBFS content. See *Oracle Database SecureFiles and Large Objects Developer's Guide* for information about DBFS.

```
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBSchema.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBStandard.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/acl.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/dav.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/stats.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/xdbconfig.xsd
/xdbconfig.xml
```

Oracle XML DB Repository Resources

Oracle XML DB Repository resources conform to the Oracle XML DB XML schema `XDBResource.xsd`. The elements in a resource include those needed to persistently store WebDAV-defined properties, such as creation date, modification date, WebDAV locks, owner, ACL, language, and character set.

> **See Also:** "XDBResource.xsd: XML Schema for Oracle XML DB Resources" on page A-1

A resource index has a special element called **`Contents`** that contains the contents of the resource.

The XML schema for a resource also defines an **`any`** element, with `maxOccurs` attribute unbounded. An `any` element can contain any element outside of the Oracle XML DB XML namespace. Arbitrary instance-defined properties can be associated with the resource.

Where Is Repository Data Stored?

Oracle XML DB stores Oracle XML DB Repository data in a set of tables and indexes to which you have access. If you register an XML schema and request that the tables be generated by Oracle XML DB, then the tables are created in your database schema. You are then able to see or modify them. Other users cannot see your tables unless you grant them permission to do so.

Names of Generated Tables

The names of the generated tables are assigned by Oracle XML DB, and can be obtained by finding the `xdb:defaultTable` attribute in your XML schema document (or in the default XML schema document). When you register an XML schema, you can alternatively provide your own table name, instead of using the default name supplied by Oracle XML DB. If the table specifies binary XML storage, then a document is encoded in binary XML format before storing it in the table.

> **See Also:** "Default Tables Created during XML Schema Registration" on page 18-4

Defining Object-Relational Storage for Resources

Applications that need to define object-relational storage for resources can do so in one of these ways:

- Subclass the Oracle XML DB resource type. Subclassing Oracle XML DB resources requires privileges on the table `XDB$RESOURCE`.
- Store data that conforms to a visible, registered XML schema.

> **See Also:** Chapter 17, "XML Schema Storage and Query: Basic"

Oracle ASM Virtual Folder

The Oracle Automatic Storage Management (Oracle ASM) virtual folder, `/sys/asm`, is an exception to the description of the previous sections: its contents are Oracle ASM files and folders that are managed automatically by Oracle ASM.

See Also:

- "Access to Oracle ASM Files Using Protocols and Resource APIs – For DBAs" on page 21-15
- *Oracle Automatic Storage Management Administrator's Guide*

How Documents are Stored in the Repository

Oracle XML DB provides special handling for XML documents. The rules for storing the contents of schema-based XML document are defined by the XML schema. The content of the document is stored in the default table associated with the global element definition.

Oracle XML DB Repository also stores files that do not contain XML data, such as JPEG images or Word documents. The XML schema for each resource defines which elements are allowed, and specifies whether the content of these files is to be stored as `BLOB` or `CLOB` instances. The content of a non-schema-based XML document is stored as a `CLOB` instance in the repository.

There is one resource and one link-properties document for each file or folder in the repository. If there are multiple access paths to a given document, there is a link-properties document for each possible link. Both the resource document and the link-properties are stored as XML documents. All these documents are stored in tables in the repository.

When an XML file is loaded into the repository, the following sequence of events takes place:

1. Oracle XML DB examines the root element of the XML document to see if it is associated with a known (registered) XML schema. This involves looking to see if the document includes a namespace declaration for the `XMLSchema-instance` namespace, and then looking for a `schemaLocation` or `noNamespaceSchemaLocation` attribute that identifies which XML schema the document is associated with.
2. If the document is based on a known XML schema, then the metadata for the XML schema is loaded from the XML schema cache.
3. The XML document is parsed and decomposed into a set of SQL objects derived from the XML schema.
4. The SQL objects created from the XML file are stored in the default table defined when the XML schema was registered with the database.
5. A resource document is created for each document processed. This lets the content of the document be accessed using the repository. The resource document for an XML schema-based `XMLType` instance includes an `XMLRef` element. This element contains a `REF` of `XMLType` that can be used to locate the row in the default table containing the content associated with the resource.

Repository Data Access Control

You can control access to the resources in Oracle XML DB Repository by using access control lists (ACLs). An ACL is a list of access control entries (ACEs), each of which

grants or denies a set of privileges to a specific principal. The principal can be a database user, a database role, an LDAP user, an LDAP group or the special principal `DAV::owner`, which refers to the owner of the resource. Each resource in the repository is protected by an ACL. The ACL determines what privileges, such as `read-properties` and `update`, a user has on the resource. Each repository operation includes a check of the ACL to determine if the current user is allowed to perform the operation.

By default, a new resource inherits the ACL of its parent folder. But you can set the ACL of a resource using PL/SQL procedure `DBMS_XDB_REPOS.setACL`. For more details on Oracle XML DB resource security, see Chapter 27, "Repository Access Control".

In the following example, the current user is `QUINE`. The query gives the number of resources in the folder `/public`. Assume that there are only two resources in this folder: `f1` and `f2`. Also assume that the ACL on `f1` grants the `read-properties` privilege to `QUINE` while the ACL on `f2` does not grant `QUINE` any privileges. A user needs the `read-properties` privilege on a resource for it to be visible to the user. The result of the query is `1`, because only `f1` is visible to `QUINE`.

```
SELECT count(*) FROM RESOURCE_VIEW r WHERE under_path(r.res, '/public') = 1;

COUNT(*)
--------
       1
```

Path-Name Resolution

The data relating a folder to its contents is managed by the Oracle XML DB hierarchical repository index. This provides a fast mechanism for evaluating path names, similar to the directory mechanisms that are used by operating-system file systems.

Resources that are folders have the `Container` attribute of element `Resource` set to `true`.

To resolve a resource name in a folder, the current user must have the following privileges:

- `resolve` privilege on the folder
- `read-properties` on the resource in that folder

If the user does not have these privileges, then the user receives an `access denied` error. Folder listings and other queries do not return a row when the `read-properties` privilege is denied on its resource.

Caution: Error handling in path-name resolution differentiates between invalid resource names and resources that are not folders, for compatibility with file systems. Because Oracle XML DB resources are accessible from outside Oracle XML DB Repository (using SQL), denying read access on a folder that contains a resource does *not prevent* read access to that resource.

See Also: "XDBResource.xsd: XML Schema for Oracle XML DB Resources" on page A-1 for the definition of element `Resource` and its attribute `Container`

Link Types

Links in Oracle XML DB can be repository links or document links. Repository links can be hard links or weak links. Document links can also be hard links or weak links, when their targets are repository resources. These terms are explained further in the following sections.

Repository and Document Links

In addition to containing resources, a folder resource can contain links to other resources (files or folders). These **repository links**, sometimes called **folder links**, are not to be confused with **document links**, which correspond to the links provided by the XLink and XInclude standards, and which are also supported by Oracle XML DB. Repository links are navigational, folder–child links among repository resources. Document links are arbitrary links among documents that are not necessarily repository resources.

Repository links represent repository hierarchical relationships. Document links represent arbitrary relationships whose semantics derives from the applications that use them. Because they represent repository hierarchical relationships, repository links can be navigated using file system-related protocols. This is not true of document links. Because document links can represent arbitrary relationships, they can also represent repository relationships. When document links thus target resources, they can also be hard or weak.

> **See Also:** Chapter 23, "How To Use XLink and XInclude with Oracle XML DB" for information about document links

Hard Links and Weak Links

Links that target repository resources can be **hard links** or **weak links**. Both hard and weak links are references, or pointers, to physical data—(internal) repository resource identifiers. They do not point to symbolic names or paths to other links. Their targets are resolved at the time of link creation. Because they point directly to resource identifiers, hard and weak links cannot dangle: they remain valid even when their targets are renamed or moved. You need the same privileges to create or delete hard and weak links.

The difference between hard and weak links lies in their relationship to target resource deletion. A target resource is dependent on its hard links, in the sense that it cannot be deleted as long as it remains the target of a hard link. Deletion of a hard link also deletes the resource targeted by the link, if the following are both true:

- The resource is not versioned.
- The hard link that was deleted was the last (that is, the only) hard link to the resource.

A weak link has no such hold on a resource: you can delete a resource, even if it is the target of a weak link (as long as it is not the target of a hard link). Because of this, weak links can be used as shortcuts to frequently accessed resources, without impacting deletion of those resources.

There is a dependency in the other direction, however: If you delete a resource that is the target of one or more weak links, then those links are automatically deleted, as well. In this sense, too, weak links cannot dangle. Both hard and weak links provide referential integrity: if a link exists, then so does its target.

Another difference between hard and weak links is this: Hard links to ancestor folders are not permitted, because they introduce cycles. There is no such restriction for weak

links: a weak link can target any folder, possibly creating a cycle. It is the set of hard links that define the (acyclic) structure of Oracle XML DB Repository. Weak links represent an additional mapping on top of that basic structure.

You can query the repository path view, PATH_VIEW, to determine the type of a repository link: the link information contains the link type. XMLType column LINK of PATH_VIEW contains this information in element LinkType, which is a child of the root element, LINK. Example 21–1 illustrates this. You can also determine the type of a repository link by using the getLink() callback function on an event handler (LinkIn, LinkTo, UnlinkIn, or UnlinkFrom).

Example 21–1 Querying PATH_VIEW to Determine Link Type

```
SELECT RESID, XMLCast(XMLQuery('/LINK/LinkType' PASSING LINK RETURNING CONTENT)
                      AS VARCHAR2(24)) link_type
  FROM PATH_VIEW WHERE equals_path(RES, '/home/QUINE/purchaseOrder.xml') = 1;

RESID                            LINK_TYPE
-------------------------------- ---------
DF9856CF2FE0829EE030578CCE0639C5 Weak
```

See Also:

- "Deleting Repository Resources: Examples" on page 24-14
- "Query-Based Access to Repository Resources" on page 21-17 for information about PATH_VIEW
- *Oracle Database PL/SQL Packages and Types Reference* for information on PL/SQL function getLink

Creating a Weak Link with No Knowledge of Folder Hierarchy

Suppose that you want to read a file resource that belongs to one of your colleagues. You cannot create a hard link to that resource, to make it accessible for your use, unless you have the privilege <xdb:resolve> on *all* of the ancestor folders of that file. Having that privilege would mean that you could see all of your colleague's folder names and the structure of the hierarchy down to the target resource.

However, because weak links essentially represent a mapping on top of the real repository structure, which structure is determined by the set of hard links, you can create a weak link to a resource using just its OID rather than its full, named path (URL). Your colleague can determine the OID path to the file, send you that instead of the named path, and you can create a weak link to the document using that OID path. Example 21–2 and Example 21–3 illustrate this.

Example 21–2 prints the OID path for the file resource /home/QUINE/purchaseOrder.xml. User quine can use this to obtain the OID path to the resource, and then send that path to user curry, who can create a weak link to the resource (Example 21–3).

Example 21–2 Obtaining the OID Path of a Resource

```
DECLARE
  resoid  RAW(16);
  oidpath VARCHAR2(100);
BEGIN
  SELECT RESID INTO resoid FROM RESOURCE_VIEW
    WHERE equals_path(RES, '/home/QUINE/purchaseOrder.xml') = 1;
    oidpath := DBMS_XDB_REPOS.createOIDPath(resoid);
  DBMS_OUTPUT.put_line(oidpath);
```

```
END;
```

In Example 21–3, user `curry` creates a weak link named `quinePurchaseOrder.xml` in folder `/home/CURRY`. The target of the link is the OID path that corresponds to the URL `/home/QUINE/purchaseOrder.xml`. User `curry` need not be aware of the repository structure that is visible to user `quine`.

Example 21–3 Creating a Weak Link Using an OID Path

```
CALL DBMS_XDB_REPOS.link(/sys/oid/1BDCB46477B59C20E040578CCE0623D3
                         '/home/CURRY', 'quinePurchaseOrder.xml',
                         DBMS_XDB_REPOS.LINK_TYPE_WEAK);
```

Restricting Multiple Hard Links

Sometimes, it is useful to restrict the creation of hard links, disallowing multiple hard links to folders or files (or both). In particular, allowing multiple hard links to file resources, but disallowing multiple hard links to folder resources, provides behavior that is similar to that for some file systems, including UNIX and Linux. This can simplify application design, by, in effect, ensuring that each file resource has a unique, canonical hard-link path to it. In addition, preventing multiple hard links to a resource can lead to query performance improvements.

You can configure the prevention of multiple hard links using the following Boolean parameters in configuration file `xdbconfig.xml`. The default value of each parameter is `true`, meaning that multiple hard links can be created.

- `folder-hard-links` – Prevent the creation of multiple hard links to a folder resource, if `false`.
- `non-folder-hard-links` – Prevent the creation of multiple hard links to a file resource, if `false`.

See Also: "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4

Navigational or Path Access to Repository Resources

Oracle XML DB Repository folders support the same protocol standards used by many operating systems. This lets a repository folder act like a native folder (directory) in supported operating-system environments. For example:

- You can use Windows Explorer to open and access repository files and folders (resources) the same way you access other files and folders in the file system, as shown in Figure 21–2.
- You can access repository data using HTTP(S)/WebDAV from a Web browser, as shown in Figure 21–3 and Figure 21–4.

  Figure 21–3 shows a browser visiting URL `http://xdbdemo:8080/`. The server it is connected to is `xdbdemo`, and its HTTP port number is `8080`.

  Figure 21–4 shows a browser using HTTP to visit an XML document (an XSL stylesheet) stored in the database. The URL is http://localhost:8080/home/SCOTT/poSource/xsl/purchaseOrder.xsl.

Figure 21–2 Oracle XML DB Folders in Windows Explorer

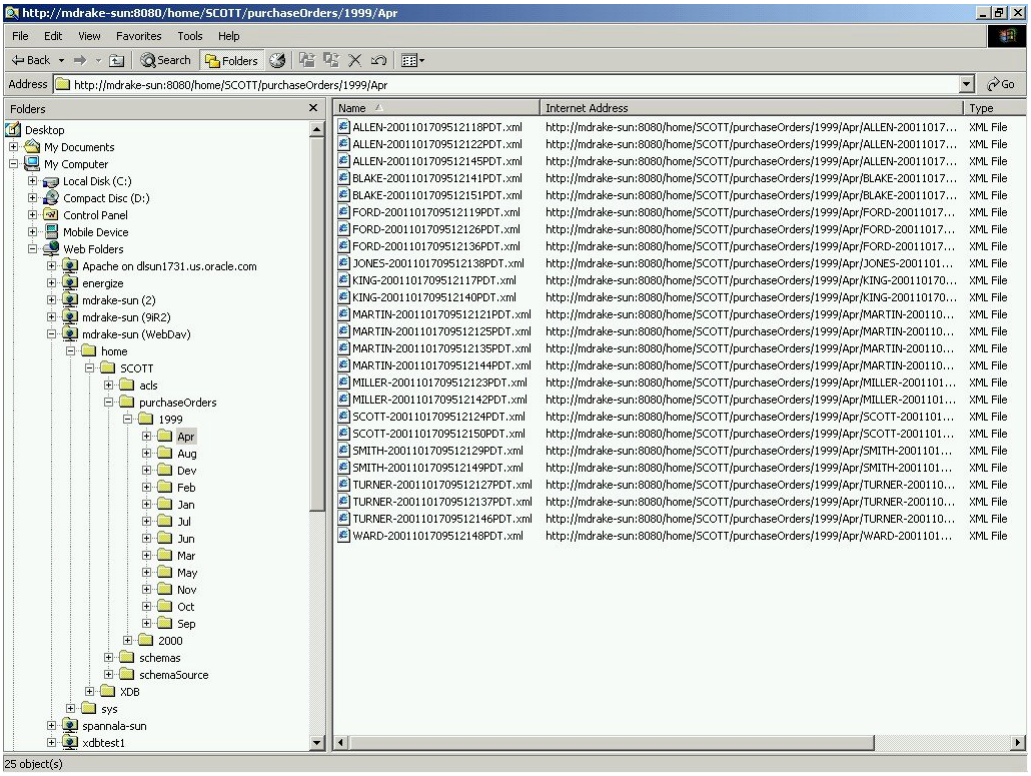


Figure 21–3 Accessing Repository Data Using HTTP(S)/WebDAV and a Web Browser

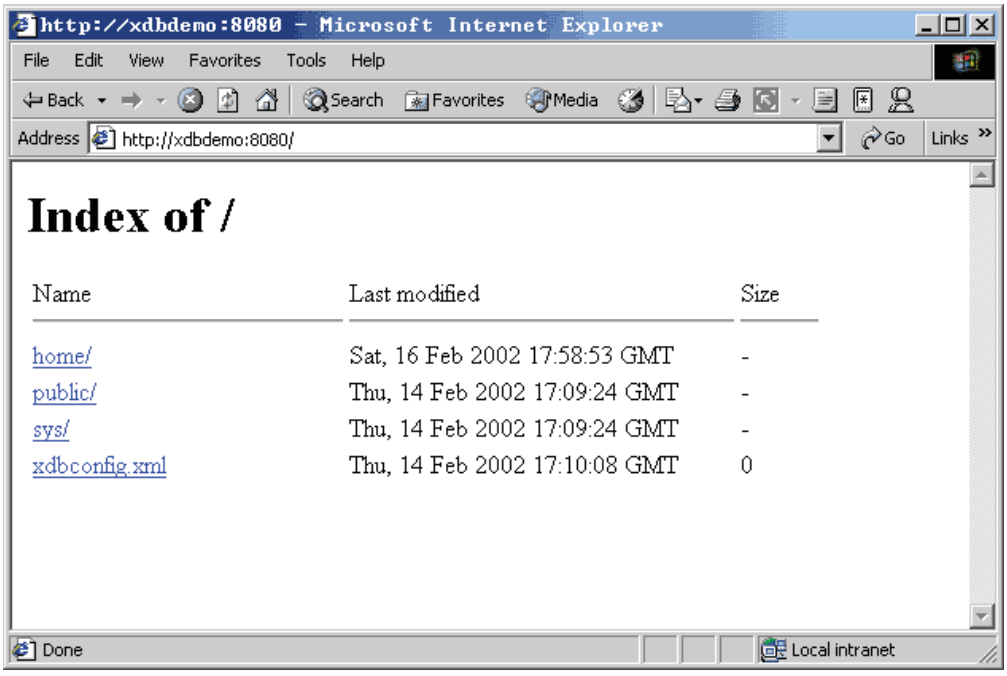
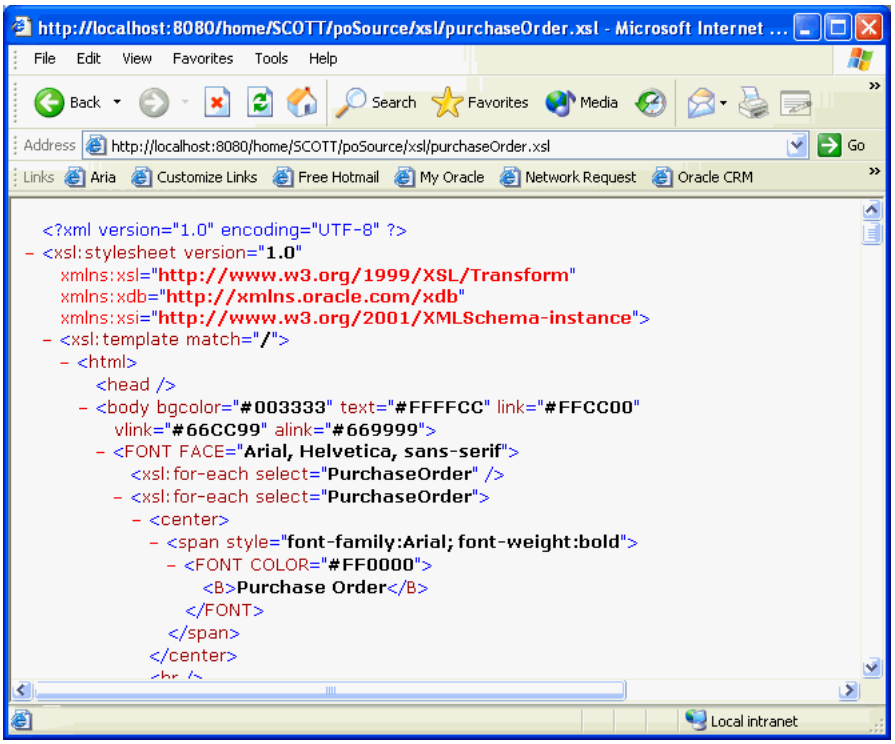


Figure 21–4 Path-Based Access Using HTTP and a URL



Access to Oracle XML DB Resources Using Internet Protocols

Oracle Net Services provides one way of accessing database resources. Oracle XML DB support for Internet protocols provides another way of accessing database resources.

Where You Can Use Oracle XML DB Protocol Access

Oracle Net Services is optimized for record-oriented data. Internet protocols are designed for stream-oriented data, such as binary files or XML text documents. Oracle XML DB protocol access is a valuable alternative to Net Services in the following scenarios:

- Direct database access from file-oriented applications using the database like a file system
- Heterogeneous application server environments that require a uniform data access method (such as XML over HTTP, which is supported by most data servers, including MS SQL Server, Exchange, Notes, many XML databases, stock quote services and news feeds)
- Application server environments that require data in the form of XML text
- Web applications that use client-side XSL to format datagrams that do not need much application processing
- Web applications that use Java servlets that run inside the database
- Web access to XML-oriented stored procedures

Overview of Protocol Access to Oracle XML DB

Accessing Oracle XML DB using a protocol proceeds as follows:

1. A connection object is established, and the protocol might read part of the request.

2. The protocol decides whether the user is already authenticated and wants to reuse an existing session or the connection must be re-authenticated (the latter is more common).
3. An existing session is pulled from the session pool, or else a new one is created.
4. If authentication has not been provided, and the request is HTTP `get` or `head`, then the session is run as the `ANONYMOUS` user. If the session has already been authenticated as the `ANONYMOUS` user, then there is no cost to reuse the existing session. If authentication has been provided, then the database re-authentication routines are used to authenticate the connection.
5. The request is parsed.
6. (HTTP only) If the requested path name maps to a servlet, then the servlet is invoked using Java Virtual Machine (JVM). The servlet code writes the response to a response stream or asks `XMLType` instances to do so.

Retrieval of Oracle XML DB Resources

When the protocol indicates that a resource is to be retrieved, the path name to the resource is resolved. Resources being fetched are always streamed out as XML, with the exception of resources containing the `XDBBinary` element, an element defined to be the XML binary data type, which have their contents streamed out in `RAW` form.

Storage of Oracle XML DB Resources

When the protocol indicates that a resource must be stored, Oracle XML DB checks the document file name extension for `.xml`, `.xsl`, `.xsd`, and so on. If the document is XML, then a pre-parse step is done, whereby enough of the resource is read to determine the XML `schemaLocation` and `namespace` of the root element in the document. If a registered schema is located at the `schemaLocation` URL, and it has a definition for the root element of the current document, then the default table specified for that root element is used to store the contents of the resource.

Internet Protocols and XMLType: XMLType Direct Stream Write

Oracle XML DB supports Internet protocols at the `XMLType` level by using Java `XMLType` method `writeToStream()`. This method is implemented natively and writes `XMLType` data directly to the protocol request stream. This avoids Java VM execution costs and the overhead of converting database data through Java data types and creating Java objects, resulting in significantly higher performance. Performance is further enhanced if the Java code deals only with XML element trees that are close to the root, and does not traverse too many of the leaf elements, so that relatively few Java objects are created.

See Also: Chapter 28, "Repository Access Using Protocols"

Access to Oracle ASM Files Using Protocols and Resource APIs – For DBAs

Oracle Automatic Storage Management (Oracle ASM) organizes database files into *disk groups* for simplified management and added benefits such as database mirroring and I/O balancing.

Repository access using protocols and resource APIs (such as `DBMS_XDB_REPOS`) extends to Oracle ASM files. These files are accessed in the *virtual* repository folder `/sys/asm`. However, this access is reserved for database administrators (DBAs). It is *not* intended for developers.

A typical use of such access is to copy Oracle ASM files from one database instance to another. For example, a DBA can view folder `/sys/asm` in a graphical user interface using the WebDAV protocol, and then drag-and-drop a copy of a data-pump dump set from an Oracle ASM disk group to an operating-system file system.

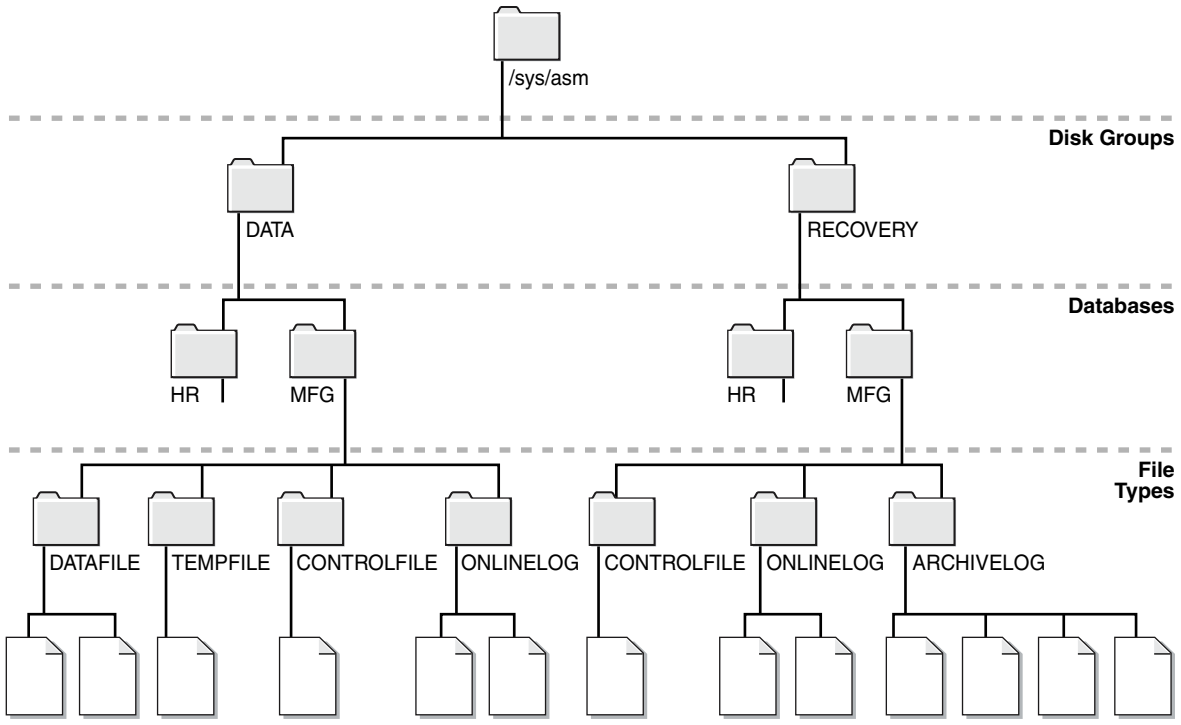
Virtual folder `/sys/asm` is created by default during Oracle XML DB installation. If the database is not configured to use Oracle ASM, the folder is empty and no operations are permitted on it.

Folder `/sys/asm` contains folders and subfolders that follow the hierarchy defined by the structure of an Oracle ASM *fully qualified filename*:

- It contains a subfolder for each mounted *disk group*.
- A disk-group folder contains a subfolder for each *database* that uses that disk group. In addition, a disk-group folder may contain files and folders corresponding to Oracle ASM *aliases* created by the administrator.
- A database folder contains file-type folders.
- A file-type folder contains Oracle ASM files, which are binary.

This hierarchy is shown in Figure 21–5, which omits directories created for aliases, for simplicity.

Figure 21–5 Oracle ASM Virtual Folder Hierarchy



The following usage restrictions apply to virtual folder `/sys/asm`. You *cannot*:

- *query* `/sys/asm` using SQL
- put regular files under `/sys/asm` (you can put only Oracle ASM files there)
- *move* (rename) an Oracle ASM file to a different Oracle ASM disk group or to a folder outside Oracle ASM
- create *hard links* to existing Oracle ASM files or directories

In addition:

- You must have the privileges of role `DBA` to view folder `/sys/asm`.
- To access `/sys/asm` using Oracle XML DB protocols, you must log in as a user other than `SYS`.

Again, Oracle ASM virtual-folder operations are intended only for *database administrators*, not developers.

See Also:

- "Using FTP with Oracle ASM Files" on page 28-14 for an example of using protocol FTP with `/sys/asm`
- *Oracle Automatic Storage Management Administrator's Guide* for information about the syntax of a fully qualified Oracle ASM filename and details on the virtual folder structure

Query-Based Access to Repository Resources

PL/SQL package `DBMS_XDB_REPOS` provides subprograms that act on repository resources. This API is based on the public views `RESOURCE_VIEW` and `PATH_VIEW`, which enable SQL access to Oracle XML DB Repository data through protocols such as FTP and HTTP(S)/WebDAV:

- `PATH_VIEW` – Has one row for each unique repository path
- `RESOURCE_VIEW` – Has one row for each resource

Through these views, you can access and update both the metadata and the content of documents stored in the repository. Operations on the views use underlying repository tables such as `XDB$RESOURCE`.

Each view contains virtual column `RES`. You use column `RES` to access and update resource documents using SQL statements that accept a repository path notation.

View `RESOURCE_VIEW` contains column `ANY_PATH`. Column `ANY_PATH` contains a valid URL that the current user can pass to PL/SQL constructor `XDBURIType` to access the resource content. If this content is not binary data, then the resource itself also contains the content.

Table 21–2 summarizes the differences between the views.

Table 21–2 Differences Between PATH_VIEW and RESOURCE_VIEW

PATH_VIEW	RESOURCE_VIEW
Contains link properties	No link properties
Has one row for each unique *path* in repository	Has one row for each *resource* in repository

Rows in these views are of data type `XMLType`. In the `RESOURCE_VIEW`, the single path associated with a resource is arbitrarily chosen from among the possible paths that refer to the resource. Oracle XML DB provides SQL functions, such as `under_path`, that let applications search for the resources contained within a particular folder (recursively), obtain the resource depth, and so on.

DML code can be used on the repository views to insert, rename, delete, and update resource properties and contents. Programmatic APIs must be used for other operations, such as creating links to existing resources.

Oracle XML DB supports the concept of **linking**. Linking makes it possible to define multiple paths to a given document. A separate XML document, called the **link-properties document**, maintains metadata properties that are specific to the path, rather than to the resource. Whenever a resource is created, an initial link is also created.

`PATH_VIEW` exposes the link-properties documents. There is one entry in `PATH_VIEW` for each possible path to a document. Column `RES` of `PATH_VIEW` contains the resource document pointed to by this link. Column `PATH` contains the path that the link lets you use to access the resource. Column `LINK` contains the link-properties document (metadata) for this `PATH`.

See Also:

- "Link Types" on page 21-10
- Chapter 24, "Repository Access Using RESOURCE_VIEW and PATH_VIEW"
- Chapter 27, "Repository Access Control"
- *Oracle Database Reference* for more information about view `PATH_VIEW`
- *Oracle Database Reference* for more information about view `RESOURCE_VIEW`

Servlet Access to Repository Resources

Oracle XML DB implements Java Servlet API, version 2.2, with the following exceptions:

- All servlets must be distributable. They must expect to run in different virtual machines.
- WAR and `web.xml` files are not supported. Oracle XML DB supports a subset of the XML configurations in this file. An XSLT stylesheet can be applied to the `web.xml` to generate servlet definitions. An external tool must be used to create database roles for those defined in the `web.xml` file.
- JSP (Java Server Pages) support can be installed as a servlet and configured manually.
- `HTTPSession` and related classes are not supported.
- Only one servlet context (that is, one Web application) is supported.

See Also: Chapter 32, "How to Write Oracle XML DB Applications in Java"

Operations on Repository Resources

You can operate on data stored in Oracle XML DB Repository resources using any of the following:

- Oracle XML DB resource APIs for Java
- A combination of Oracle XML DB resource views API and Oracle XML DB resource API for PL/SQL

- Internet protocols (HTTP(S)/WebDAV and FTP) and Oracle XML DB protocol server
- Oracle XML DB Content Connector and, through it, the standard Content Repository API for Java (JCR).

These access methods can be used equivalently. It does not matter how you add content to the repository or retrieve it from there. For example, you can add content to the repository using SQL or PL/SQL and then retrieve it using an Internet protocol,or the other way around.

Table 21–3 lists common Oracle XML DB Repository operations, and describes how these operations can be accomplished using each of several access methods. The table shows functionality common to the different methods, but not all of the methods are equally suited to any particular task. Unless mentioned otherwise, "resource" in this table can be either a file resource or a folder resource.

Table 21–3 also shows the resource privileges that are required for each operation.

Table 21–3 Accessing Oracle XML DB Repository: API Options

Data Access	SQL and PL/SQL	Protocols	Resource Privileges Required	JCR Support
Create resource	`DBMS_XDB_REPOS.createResource( '/public/T1/testcase.txt', 'ORIGINAL text'); INSERT INTO RESOURCE_VIEW (ANY_PATH, RES) SELECT '/public/T1/copy1.txt', RES FROM RESOURCE_VIEW WHERE equals_path(RES, '/public/T1/testcase.txt') = 1;`	HTTP:`PUT`; FTP: `PUT`	`DAV::bind` on parent folder	Yes
Update resource contents	`UPDATE RESOURCE_VIEW SET RES = XMLQuery('declare default element namespace "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :) copy $i := $p1 modify (for $j in $i/Resource/Contents/text return replace value of node $j with $p2) return $i' PASSING RES AS "p1", 'NEW text' AS "p2" RETURNING CONTENT) WHERE equals_path(RES, '/public/T1/copy1.txt') = 1`	HTTP: `PUT`; FTP: `PUT`	`xdb:write-content` on resource	Yes
Update resource properties	`UPDATE RESOURCE_VIEW SET RES = XMLQuery('declare default element namespace "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :) copy $i := $p1 modify (for $j in $i/Resource/DisplayName return replace value of node $j with $p2) return $i' PASSING RES AS "p1", 'NewName1.txt' AS "p2" RETURNING CONTENT) WHERE equals_path(RES, '/public/T1/copy1.txt') = 1;`	WebDAV: `PROPPATCH`;	`DAV::write-properties` on resource	Yes
Update resource ACL	`EXEC DBMS_XDB_REPOS.setACL( '/public/T1/copy1.txt', '/sys/acls/all_owner_acl.xml');`	not applicable	`DAV::write-acl` on resource	No

Table 21–3 (Cont.) Accessing Oracle XML DB Repository: API Options

Data Access	SQL and PL/SQL	Protocols	Resource Privileges Required	JCR Support

Unlink resource (delete if last link)	`EXEC DBMS_XDB_REPOS.deleteResource()`
	or
	`DELETE FROM RESOURCE_VIEW`
	`WHERE equals_path(RES, path) > 0`
		HTTP:
		`DELETE;`
		FTP:
		`delete`
			`DAV::unbind` on parent folder
			`xdb:unlink-from` on resource
				Yes

Forcibly remove all links to resource	`DBMS_XDB_REPOS.deleteResource()`
	or
	`DELETE FROM PATH_VIEW`
	`WHERE`
	`XMLCast(`
	`XMLQuery(`
	`'declare namespace n1=`
	`"http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)`
	`//n1:DisplayName'`
	`PASSING RES RETURNING CONTENT)`
	`AS VARCHAR2(256))`
	`= 'My resource'`
		FTP:
		`quote`
		`rm_rf`
		`resource`
			`DAV::unbind` on all parent folders
			`xdb:unlink-from` on resource
				Yes

Move resource	`UPDATE PATH_VIEW`
	`SET path = '/public/T1/copy2.txt'`
	`WHERE equals_path(RES,`
	`'/public/T1/copy1.txt')`
	`= 1;`
		WebDAV:
		`MOVE;`
		FTP:
		`rename`
			`DAV::unbind` on source parent folder
			`DAV::bind` on target parent folder
			`xdb:unlink-from` and `xdb:link-to` on resource
				Yes

Copy resource	`INSERT INTO PATH_VIEW (path, RES, link)`
	`SELECT '/public/T1/copy3.txt', RES, link`
	`FROM PATH_VIEW`
	`WHERE equals_path(RES,`
	`'/public/T1/copy2.txt')`
	`= 1;`
		WebDAV:
		`COPY;`
			Copy to new:
			`DAV::bind` on target parent folder
			`DAV::read` on resource
			
			Copy to existing (replacement):
			`DAV::read` on resource
			`DAV::write-properties` and `DAV::write-content` on existing target resource
				Yes

Create hard link to existing resource	`EXEC DBMS_XDB_REPOS.link('/public/T1/copy3.txt',`
	`'/public/T1',`
	`'myhardlink');`
		not applicable	`DAV::bind` on parent folder
			`xdb:link-to` on resource
				No

Create weak link to existing resource	`EXEC DBMS_XDB_REPOS.link(`
	`'/public/T1/copy3.txt',`
	`'/public/T1',`
	`'myweaklink',`
	`DBMS_XDB_REPOS.LINK_TYPE_WEAK);`
		not applicable	`DAV::bind` on parent folder
			`xdb:link-to` on resource
				No

Change owner of resource	`UPDATE RESOURCE_VIEW`
	`SET RES =`
	`XMLQuery(`
	`'copy $i := $p1 modify`
	`(for $j in $i/Resource/Owner`
	`return replace value of node $j with $p2)`
	`return $i'`
	`PASSING RES AS "p1", 'U2' AS "p2" RETURNING`
	`CONTENT)`
	`WHERE equals_path(RES, '/public/T1/copy3.txt') = 1;`
		not applicable	`DAV::take-ownership` on resource	Yes

Table 21–3 (Cont.) Accessing Oracle XML DB Repository: API Options

Data Access	SQL and PL/SQL	Protocols	Resource Privileges Required	JCR Support

Get binary or text representation of resource contents	`SELECT XDBURIType(path).getBLOB()`
	`  FROM DUAL;`
	
	`SELECT`
	`XMLQuery(`
	`'declare default element namespace`
	`"http://xmlns.oracle.com/xdb/XDBResource.xsd";(: :)`
	`  $r/Resource/Contents'`
	`PASSING RES AS "r" RETURNING CONTENT)`
	`FROM RESOURCE_VIEW`
	`WHERE equals_path(RES, '/public/T1/copy2.text') = 1;`
		HTTP: `GET;`
		FTP: `get`
			`xdb:read-contents` on resource	Yes

Get `XMLType` representation of resource contents	`SELECT XDBURIType('/public/T1/res.xml').getXML`
	`  FROM DUAL;`
	
	`SELECT`
	`XMLQuery(`
	`'declare default element namespace`
	`"http://xmlns.oracle.com/xdb/XDBResource.xsd";(: :)`
	`  $r/Resource/Contents/*'`
	`PASSING RES AS "r" RETURNING CONTENT)`
	`FROM RESOURCE_VIEW`
	`WHERE equals_path(RES, '/public/T1/res.xml') = 1;`
		not applicable	`xdb:read-contents` on resource	No

Get resource properties	`SELECT`
	`XMLCast(`
	`XMLQuery(`
	`'declare default element namespace`
	`"http://xmlns.oracle.com/xdb/XDBResource.xsd";(: :)`
	`$r/Resource/LastModifier'`
	`PASSING RES AS "r" RETURNING CONTENT)`
	`AS VARCHAR2(128))`
	`FROM RESOURCE_VIEW`
	`WHERE equals_path(RES, '/public/T1/res.xml') = 1;`
		WebDAV: `PROPFIND (depth = 0);`	`xdb:read-properties` on resource	Yes

List resources in folder	`SELECT PATH FROM PATH_VIEW` `  WHERE under_path(res, '/public/T1') = 1;`	WebDAV: `PROPFIND (depth = 0);`	`xdb:read-contents` on folder	Yes
Create folder	`Call DBMS_XDB_REPOS.createFolder('/public/T2');`	WebDAV: `MKCOL;` FTP: `mkdir`	`DAV::bind` on parent folder	Yes
Unlink empty folder	`DBMS_XDB_REPOS.deleteResource('/public/T2')`	HTTP: `DELETE;` FTP: `rmdir`	`DAV::unbind` on parent folder `xdb:unlink-from` on resource	Yes

Forcibly delete folder and all links to it	`DBMS_XDB_REPOS.deleteResource(`
	`  '/public/T2',`
	`  DBMS_XDB.DELETE_RECURSIVE_FORCE);`
		not applicable	`DAV::unbind` on all parent folders
			`xdb:unlink-from` on folder resource
				Yes

Get resource with a row lock	`SELECT ...`
	`  FROM RESOURCE_VIEW`
	`  FOR UPDATE ...;`
		not applicable	`xdb:read-properties` and `xdb:read-contents` on resource	No

Add WebDAV lock on resource	`EXEC DBMS_XDB_REPOS.LockResource(`
	`  '/public/T1/res.xml',`
	`  TRUE,`
	`  TRUE);`
		WebDAV: `LOCK;`
		FTP: `quote lock`
			`DAV::write-properties` on resource	No

Table 21–3 (Cont.) Accessing Oracle XML DB Repository: API Options

Data Access	SQL and PL/SQL	Protocols	Resource Privileges Required	JCR Support

Remove WebDAV lock	`DECLARE...`
	`BEGIN`
	`DBMS_XDB_REPOS.GetLockToken('/public/T1/res.xml', locktoken);`
	`DBMS_XDB_REPOS.UnlockResource('/public/T1/res.xml', locktoken);`
	`END;`
		WebDAV: `UNLOCK;`
		FTP: `quote unlock`
			`DAV::write-properties` and `DAV::unlock` on resource	No

Check out file resource	`EXEC DBMS_XDB_VERSION.checkOut('/public/T1/res.xml');`	not applicable	`DAV::write-properties` on resource	No
Check in file resource	`EXEC DBMS_XDB_VERSION.checkIn('/public/T1/res.xml');`	not applicable	`DAV::write-properties` on resource	No
Uncheck out file resource	`EXEC DBMS_XDB_VERSION.unCheckOut('/public/T1/res.xml');`	not applicable	`DAV::write-properties` on resource	No
Make file resource versioned	`EXEC DBMS_XDB_VERSION.makeVersioned('/public/T1/res.xml');`	not applicable	`DAV::write-properties` on resource	No
Remove an event handler	`DBMS_XEVENT.remove`	not applicable	`xdb:write-config` on resource or parent folder (depending on the context)	No
Commit changes	`COMMIT;`	Automatic commit after each request	not applicable	Yes
Rollback changes	`ROLLBACK;`	not applicable	not applicable	Yes

In addition to the privileges listed in Table 21–3, privilege `xdb:read-properties` is required on each resource affected by an operation. Operations that affect the parent folder of a resource, in addition to the resource targeted by the operation, also require privilege `xdb:read-properties` on that parent folder. For example, deleting a resource affects both the resource to delete and its parent folder, so you need privilege `xdb:read-properties` on both the resource and its parent folder.

See Also:

- Chapter 24, "Repository Access Using RESOURCE_VIEW and PATH_VIEW"
- Chapter 26, "PL/SQL Access to Oracle XML DB Repository"
- Chapter 28, "Repository Access Using Protocols"
- Chapter 31, "Oracle XML DB Content Connector"
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XDB_REPOS`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XDB_VERSION`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XEVENT`

Accessing the Content of Repository Resources Using SQL

You can access the content of Oracle XML DB Repository resources in several ways. The easiest way is to use PL/SQL constructor `XDBURIType`. You pass a URL to `XDBURIType` to specify which resource to access. The URL passed to the `XDBURIType` is assumed to start at the root of the repository. Object type `XDBURIType` provides methods `getBLOB()`, `getCLOB()`, and `getXML()`, to access the different kinds of content that can be associated with a resource.

Example 21–4 shows how to use constructor `XDBURIType` to access the content of the text document:

Example 21–4 Accessing a Text Document in the Repository Using XDBURITYPE

```
SELECT XDBURIType('/home/QUINE/NurseryRhyme.txt').getCLOB() FROM DUAL;

XDBURITYPE('/HOME/QUINE/NURSERYRHYME.TXT').GETCLOB()
--------------------------------------------------
Mary had a little lamb
Its fleece was white as snow
and everywhere that Mary went
that lamb was sure to go

1 row selected.
```

The contents of a document can also be accessed using the resource document. Example 21–5 shows how to access the content of a text document:

Example 21–5 Accessing Resource Content Using RESOURCE_VIEW

```
SELECT CONTENT
  FROM RESOURCE_VIEW,
       XMLTable(XMLNAMESPACES (default 'http://xmlns.oracle.com/xdb/XDBResource.xsd'),
                '/Resource/Contents' PASSING RES
                COLUMNS content CLOB PATH 'text')
  WHERE equals_path(RES, '/home/QUINE/NurseryRhyme.txt') = 1;

CONTENT
-------
Mary had a little lamb
Its fleece was white as snow
and everywhere that Mary went
that lamb was sure to go

1 row selected.
```

The content of non-schema-based and schema-based XML documents can also be accessed through a resource. Example 21–6 shows how to use an XPath expression that includes nodes from a resource document and nodes from an XML document to access the contents of a `PurchaseOrder` document using the resource.

Example 21–6 Accessing XML Documents Using Resource and Namespace Prefixes

```
SELECT des.description
  FROM RESOURCE_VIEW rv,
       XMLTable(XMLNAMESPACES ('http://xmlns.oracle.com/xdb/XDBResource.xsd' AS "r"),
                '/r:Resource/r:Contents/PurchaseOrder/LineItems/LineItem'
                PASSING rv.RES
                COLUMNS description VARCHAR2(256) PATH 'Description') des
  WHERE
```

```
    equals_path(rv.RES, '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml') = 1;

DES.DESCRIPTION
--------------------------------
A Night to Remember
The Unbearable Lightness Of Being
The Wizard of Oz

3 rows selected.
```

In Example 21–6, the namespace prefix, `r` identifies which nodes in the XPath expression are members of the resource namespace. Namespace prefix `r` is defined using the `XMLNAMESPACES` clause of SQL/XML function `XMLTable`. The namespace declaration is needed here because the purchase-order XML schema does not define a namespace, and it is not possible to apply a namespace prefix to nodes in the `PurchaseOrder` document.

> **See Also:** Chapter 4, "XQuery and Oracle XML DB" for more information about the `XMLNAMESPACES` clause of `XMLTable`

Accessing the Content of XML Schema-Based Documents

The content of a schema-based XML document can be accessed in two ways.

- In the same manner as for non-schema-based XML documents, by using the resource document. This lets `RESOURCE_VIEW` be used to query different types of schema-based XML documents with a single SQL statement.
- As a row in the default table that was defined when the XML schema was registered with Oracle XML DB.

Accessing Resource Content Using Element XMLRef in Joins

The `XMLRef` element in the resource document provides the join key required when a SQL statement needs to access or update metadata and content as part of a single operation.

The following queries use joins based on the value of element `XMLRef` to access resource content.

Example 21–7 locates a row in the `defaultTable` based on a path in Oracle XML DB Repository. SQL function `ref` locates the target row in the default table, based on the value of the `XMLRef` element in the resource document, `RES`.

Example 21–7 Querying Repository Resource Data Using SQL Function REF and Element XMLRef

```
SELECT des.description
  FROM RESOURCE_VIEW rv,
       purchaseorder p,
       XMLTable('$p/PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE AS "p"
                COLUMNS description VARCHAR2(256) PATH 'Description') des
  WHERE equals_path(rv.RES, '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml')
        = 1
    AND ref(p) = XMLCast(XMLQuery('declare default element namespace
                                  "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                                  fn:data(/Resource/XMLRef)' PASSING rv.RES RETURNING CONTENT)
                         AS REF XMLType);

DES.DESCRIPTION
--------------------------------
```

```
A Night to Remember
The Unbearable Lightness Of Being
The Wizard of Oz

3 rows selected.
```

Example 21–8 shows how to select fragments from XML documents based on metadata, path, and content. The query returns the value of element `Reference` for documents under `/home/QUINE/PurchaseOrders/2002/Mar` that contain orders for part number 715515009058.

Example 21–8 Selecting XML Document Fragments Based on Metadata, Path, and Content

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30))
  FROM RESOURCE_VIEW rv, purchaseorder po
  WHERE under_path(rv.RES, '/home/QUINE/PurchaseOrders/2002/Mar') = 1
    AND ref(po) = XMLCast(
                    XMLQuery('declare default element namespace
                              "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                              fn:data(/Resource/XMLRef)'
                             PASSING rv.RES RETURNING CONTENT)
                           AS REF XMLType)
    AND XMLExists('$p/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
CJOHNSON-20021009123335851PDT
LSMITH-2002100912333661PDT
SBELL-2002100912333601PDT

3 rows selected.
```

In general, when accessing the content of schema-based XML documents, joining `RESOURCE_VIEW` or `PATH_VIEW` with the default table is more efficient than using `RESOURCE_VIEW` or `PATH_VIEW` on its own. An explicit join between the resource document and the default table tells Oracle XML DB that the SQL statement works on only one type of XML document. XPath rewrite can thus be used to optimize operations on the default table and the resource.

Updating the Content of Documents Stored in the Repository

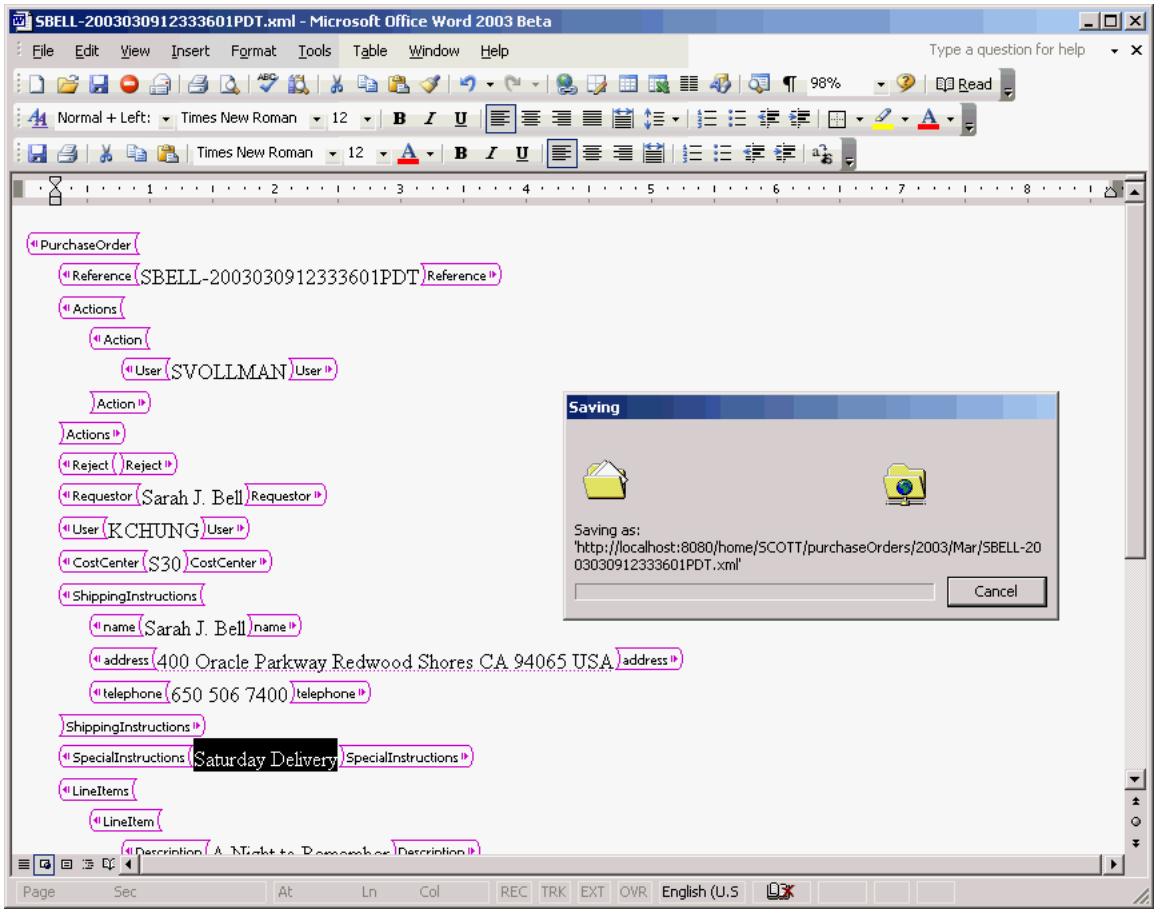
You can update the content of documents stored in Oracle XML DB Repository using protocols or SQL.

Updating Repository Content Using Protocols

The most popular content authoring tools support HTTP, FTP, and WebDAV protocols. These tools can use a URL and the HTTP verb `get` to access the content of a document, and the HTTP verb `put` to save the contents of a document. Hence, given the appropriate access permissions, a simple URL is all you need to access and edit content stored in Oracle XML DB Repository.

Figure 21–6 shows how, with the WebDAV support included in Microsoft Word, you can use Microsoft Word to update and edit a document stored in Oracle XML DB Repository.

Figure 21–6 Updating and Editing Content Stored in Oracle XML DB Using Microsoft Word



When an editing application such as Microsoft Word updates an XML document that is stored in Oracle XML DB, the database receives an input stream containing the new content of the document. Unfortunately, applications such as Word do not provide Oracle XML DB with any way of identifying which changes have taken place in the document.Partial updates are thus impossible. It is necessary to parse the entire document again, replacing all of the objects derived from the original document with objects derived from the new content.

Updating Repository Content Using SQL

You can use XQuery Update to update the content of any document stored in Oracle XML DB Repository. The content of the document can be modified by updating the resource document or by updating the default table that holds the content of the document.

Updating XML Schema-Based Documents in the Repository by Updating the Resource Document

Example 21–9 shows how to update the contents of a simple text document using a SQL `UPDATE` statement and SQL function `XMLQuery` with XQuery Update. An XQuery

expression is passed to `XMLQuery` as the target of the update operation, identifying the text node belonging to element `/Resource/Contents/text`.

Example 21–9 Updating a Document Using UPDATE and XQuery Update on the Resource

```
DECLARE
  file         BFILE;
  contents     CLOB;
  dest_offset  NUMBER := 1;
  src_offset   NUMBER := 1;
  lang_context NUMBER := 0;
  conv_warning NUMBER := 0;
BEGIN
  file := bfilename('XMLDIR', 'tdadxdb-03-02.txt');
  DBMS_LOB.createTemporary(contents, true, DBMS_LOB.SESSION);
  DBMS_LOB.fileopen(file, DBMS_LOB.file_readonly);
  DBMS_LOB.loadClobfromFile(contents,
                            file,
                            DBMS_LOB.getLength(file),
                            dest_offset,
                            src_offset,
                            nls_charset_id('AL32UTF8'),
                            lang_context,
                            conv_warning);
  DBMS_LOB.fileclose(file);
  UPDATE RESOURCE_VIEW
    SET RES =
      XMLQuery('declare default element namespace
                  "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                copy $i := $p1 modify
                  (for $j in $i/Resource/Contents/text
                   return replace value of node $j with $p2)
                return $i'
               PASSING RES AS "p1", CONTENTS AS "p2" RETURNING CONTENT)
    WHERE equals_path(res, '/home/QUINE/NurseryRhyme.txt') = 1;
  DBMS_LOB.freeTemporary(contents);
END;
/
```

This technique for updating the content of a document by updating the associated resource has the advantage that it can be used to update any kind of document stored in Oracle XML DB Repository.

Example 21–10 shows how to update a node in an XML document by performing an update on the resource document. Here, XQuery Update is used to change the value of the text node associated with element `User`.

Example 21–10 Updating a Node Using UPDATE and XQuery Update

```
UPDATE RESOURCE_VIEW
  SET RES =
    XMLQuery('declare namespace r="http://xmlns.oracle.com/xdb/XDBResource.xsd";
              copy $i := $p1 modify
                (for $j in $i/r:Resource/r:Contents/PurchaseOrder/User
                 return replace value of node $j with $p2)
              return $i'
             PASSING RES AS "p1", 'SKING' AS "p2" RETURNING CONTENT)
    WHERE equals_path(res, '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml')
          = 1;
```

```
1 row updated.

SELECT XMLCast(XMLQuery(
                 'declare namespace ns="http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                  $r/ns:Resource/ns:Contents/PurchaseOrder/User/text()'
                 PASSING RES AS "r" RETURNING CONTENT)
               AS VARCHAR2(32))
  FROM RESOURCE_VIEW
  WHERE equals_path(RES,
                    '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-20021009123336601PDT.xml')
        = 1;

XMLCAST(XMLQUERY('DECLARENAMESPA
--------------------------------
SKING

1 row selected.
```

Updating XML Schema-Based Documents in the Repository by Updating the Default Table

You can update XML schema-based XML documents by performing the update operation directly on the default table that is used to manage the content of the document. If the document must be located by a `WHERE` clause that includes a path or conditions based on metadata, then the `UPDATE` statement must use a join between the resource and the default table.

In general, when updating the contents of XML schema-based XML documents, joining the `RESOURCE_VIEW` or `PATH_VIEW` with the default table is more efficient than using the `RESOURCE_VIEW` or `PATH_VIEW` on its own. The explicit join between the resource document and the default table tells Oracle XML DB that the SQL statement works on only one type of XML document. This lets a partial update be used on the default table and resource.

In Example 21–11, XQuery Update is used on the default table, with the target row identified by a path. The row to be updated is identified by a `REF`. The `REF` is identified by a repository path using SQL function `equals_path`. This limits the update to the row corresponding to the resource identified by the specified path.

Example 21–11 Updating XML Schema-Based Documents in the Repository

```
UPDATE purchaseorder p
  SET p.OBJECT_VALUE =
    XMLQuery('copy $i := $p1 modify
                (for $j in $i/PurchaseOrder/User
                 return replace value of node $j with $p2)
              return $i'
             PASSING p.OBJECT_VALUE AS "p1", 'SBELL' AS "p2" RETURNING CONTENT)
    WHERE ref(p) =
      (SELECT XMLCast(XMLQuery('declare default element namespace
                                  "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                                fn:data(/Resource/XMLRef)'
                               PASSING rv.RES RETURNING CONTENT) AS REF XMLType)
         FROM RESOURCE_VIEW rv
         WHERE equals_path(rv.RES,
                           '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-20021009123336601PDT.xml')
               = 1);

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/User/text()'
```

```
                      PASSING p.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(32))
  FROM purchaseorder p, RESOURCE_VIEW rv
  WHERE ref(p) = XMLCast(XMLQuery('declare default element namespace
                                "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                                fn:data(/Resource/XMLRef)' PASSING rv.RES RETURNING CONTENT)
                     AS REF XMLType)
    AND equals_path(rv.RES, '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml')
        = 1;

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
SBELL
```

Querying Resources in RESOURCE_VIEW and PATH_VIEW

Oracle XML DB provides two SQL functions, `equals_path` and `under_path`, that can be used to perform **folder-restricted queries**. Such queries limit SQL statements that operate on the `RESOURCE_VIEW` or `PATH_VIEW` to documents that are at a particular location in Oracle XML DB folder hierarchy. Function `equals_path` restricts the statement to a single document identified by the specified path. Function `under_path` restricts the statement to those documents that exist beneath a certain point in the hierarchy.

The following examples demonstrate simple folder-restricted queries against resource documents stored in `RESOURCE_VIEW` and `PATH_VIEW`.

The query in Example 21–12 uses SQL function `equals_path` and `RESOURCE_VIEW` to access a resource. The resource queried is that which results from the update operation of Example 21–9: the original resource text shown in Example 21–4 and Example 21–5 has been replaced by a different nursery rhyme, "Hickory Dickory Dock..."

Example 21–12 Accessing Resources Using EQUALS_PATH and RESOURCE_VIEW

```
SELECT XMLSerialize(DOCUMENT r.res AS CLOB)
  FROM RESOURCE_VIEW r
  WHERE equals_path(res, '/home/QUINE/NurseryRhyme.txt') = 1;

XMLSERIALIZE(DOCUMENTR.RESASCLOB)
--------------------------------------------------------------------------------
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd"
          Hidden="false"
          Invalid="false"
          Container="false"
          CustomRslv="false"
          VersionHistory="false"
          StickyRef="true">
  <CreationDate>2005-06-13T13:19:20.566623</CreationDate>
  <ModificationDate>2005-06-13T13:19:22.997831</ModificationDate>
  <DisplayName>NurseryRhyme.txt</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>text/plain</ContentType>
  <RefCount>1</RefCount>
  <ACL>
    <acl description=
         "Private:All privileges to OWNER only and not accessible to others"
         xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
```

```
                 http://xmlns.oracle.com/xdb/acl.xsd"
                 shared="true">
               <ace>
                 <grant>true</grant>
                 <principal>dav:owner</principal>
                 <privilege>
                   <all/>
                 </privilege>
               </ace>
             </acl>
           </ACL>
           <Owner>QUINE</Owner>
           <Creator>QUINE</Creator>
           <LastModifier>QUINE</LastModifier>
           <SchemaElement>http://xmlns.oracle.com/xdb/XDBSchema.xsd#text</SchemaElement>
           <Contents>
             <text>Hickory Dickory Dock
The Mouse ran up the clock
The clock struck one
The Mouse ran down
Hickory Dickory Dock
             </text>
           </Contents>
</Resource>

1 row selected.
```

As Example 21–12 shows, a resource document is an XML document that captures the set of metadata defined by the DAV standard. The metadata includes information such as `CreationDate`, `Creator`, `Owner`, `ModificationDate`, and `DisplayName`. The content of the resource document can be queried and updated just like any other XML document, using SQL/XML access and query functions.

The query in Example 21–13 finds a path to each of the XSL stylesheets stored in Oracle XML DB Repository. It performs a search based on the `DisplayName` ending in `.xsl`.

Example 21–13 Determining the Path to XSLT Stylesheets Stored in the Repository

```
SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE XMLCast(XMLQuery(
                  'declare namespace ns="http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                   $r/ns:Resource/ns:DisplayName'
                  PASSING RES AS "r" RETURNING CONTENT)
                AS VARCHAR2(100))
        LIKE '%.xsl';

ANY_PATH
----------------------------------------
/home/MDSYS/epsg/sdoepsggrid2nadcon.xsl
/home/MDSYS/epsg/sdoepsggrid2ntv2/xsl
/source/schemas/poSource/xsl/empdept.xsl
/source/schemas/poSource/xsl/purchaseOrder.xsl

4 rows selected.
```

The query in Example 21–14 counts the number of resources (files and folders) under the path `/home/QUINE/PurchaseOrders`. Using `RESOURCE_VIEW` rather than `PATH_VIEW` ensures that any resources that are the target of multiple links are only counted once.

SQL function `under_path` restricts the result set to documents that can be accessed using a path that starts from `/home/QUINE/PurchaseOrders`.

Example 21–14 Counting Resources Under a Path

```
SELECT count(*)
   FROM RESOURCE_VIEW
   WHERE under_path(RES, '/home/QUINE/PurchaseOrders') = 1;

  COUNT(*)
----------
       145

1 row selected.
```

The query in Example 21–15 lists the contents of the folder identified by path `/home/QUINE/PurchaseOrders/2002/Apr`. This is effectively a directory listing of the folder.

Example 21–15 Listing the Folder Contents in a Path

```
SELECT PATH
  FROM PATH_VIEW
  WHERE under_path(RES, '/home/QUINE/PurchaseOrders/2002/Apr') = 1;

PATH
--------------------------------------------------------------------------------
/home/QUINE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336271PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/EABEL-20021009123336251PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/PTUCKER-20021009123336191PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/PTUCKER-20021009123336291PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SBELL-20021009123336231PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SBELL-20021009123336331PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SKING-20021009123336321PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SMCCAIN-20021009123336151PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SMCCAIN-20021009123336341PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/VJONES-20021009123336301PDT.xml

11 rows selected.
```

The query in Example 21–16 lists the set of links contained in the folder identified by the path `/home/QUINE/PurchaseOrders/2002/Apr` where the `DisplayName` element in the associated resource starts with `S`.

Example 21–16 Listing the Links Contained in a Folder

```
SELECT PATH
  FROM PATH_VIEW
  WHERE XMLCast(XMLQuery(
                  'declare namespace ns="http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                   $r/ns:Resource/ns:DisplayName'
                  PASSING RES AS "r" RETURNING CONTENT)
                AS VARCHAR2(100))
        LIKE 'S%'
    AND under_path(RES, '/home/QUINE/PurchaseOrders/2002/Apr') = 1;

PATH
--------------------------------------------------------------------------------
/home/QUINE/PurchaseOrders/2002/Apr/SBELL-20021009123336231PDT.xml
```

```
/home/QUINE/PurchaseOrders/2002/Apr/SBELL-20021009123336331PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SKING-20021009123336321PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SMCCAIN-20021009123336151PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SMCCAIN-20021009123336341PDT.xml

5 rows selected.
```

The query in Example 21–17 finds a path to each resource in Oracle XML DB Repository that contains a `PurchaseOrder` document. The documents are identified based on the metadata property `SchemaElement` that identifies the XML schema URL and global element for schema-based XML data stored in the repository.

Example 21–17 Finding Paths to Resources that Contain Purchase-Order XML Documents

```
SELECT ANY_PATH
  FROM RESOURCE_VIEW
 WHERE XMLExists(
         'declare namespace ns="http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
          $r/ns:Resource[ns:SchemaElement=
          "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd#PurchaseOrder"]'
         PASSING RES AS "r");
```

The query returns the following paths, each of which contains a `PurchaseOrder` document:

```
ANY_PATH
--------------------------------------------------------------------------------
/home/QUINE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336271PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/EABEL-20021009123336251PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/PTUCKER-20021009123336191PDT.xml

...

132 rows selected.
```

Oracle XML DB Hierarchical Repository Index

In a conventional relational database, path-based access and folder-restricted queries are implemented using `CONNECT BY` operations. Such queries are expensive, so path-based access and folder-restricted queries would become inefficient as the number of documents and depth of the folder hierarchy increase.

To address this issue, Oracle XML DB introduces a new index type, the **hierarchical repository index**. This lets the database resolve folder-restricted queries without relying on a `CONNECT BY` operation. Because of this, Oracle XML DB can execute path-based and folder-restricted queries efficiently. The hierarchical repository index is implemented as an Oracle domain index. This is the same technique used to add Oracle Text indexing support and many other advanced index types to the database.

Example 21–18 shows the execution plan output generated for a folder-restricted query. As shown, the hierarchical repository index `XDBHI_IDX` is used to resolve the query.

Example 21–18 Execution Plan Output for a Folder-Restricted Query

```
SELECT PATH
  FROM PATH_VIEW
  WHERE XMLCast(
          XMLQuery(
```

```
           'declare namespace ns="http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
            $r/ns:Resource/ns:DisplayName'
           PASSING RES AS "r" RETURNING CONTENT)
         AS VARCHAR2(100))
       LIKE 'S%'
   AND under_path(RES, '/home/QUINE/PurchaseOrders/2002/Apr') = 1;

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------------------
Plan hash value: 2568289845

------------------------------------------------------------------------------------------------------
| Id  | Operation                           | Name          | Rows  | Bytes | Cost (%CPU)| Time     |
------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                    |               |    17 |  3111 |    34   (6)| 00:00:01 |
|   1 |  NESTED LOOPS                       |               |    17 |  3111 |    34   (6)| 00:00:01 |
|   2 |   NESTED LOOPS                      |               |    17 |  2822 |    34   (6)| 00:00:01 |
|   3 |    NESTED LOOPS                     |               |   466 | 63842 |    34   (6)| 00:00:01 |
|*  4 |     TABLE ACCESS BY INDEX ROWID     | XDB$RESOURCE  |     1 |   135 |     3   (0)| 00:00:01 |
|*  5 |      DOMAIN INDEX                   | XDBHI_IDX     |       |       |            |          |
|   6 |     COLLECTION ITERATOR PICKLER FETCH|               |       |       |            |          |
|*  7 |    INDEX UNIQUE SCAN                | XDB_PK_H_LINK |     1 |    28 |     0   (0)| 00:00:01 |
|*  8 |   INDEX UNIQUE SCAN                 | SYS_C003900   |     1 |    17 |     0   (0)| 00:00:01 |
------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   4 - filter(CAST("P"."SYS_NC00011$" AS VARCHAR2(100)) LIKE 'S%')
   5 - access("XDB"."UNDER_PATH"(SYS_MAKEXML('8758D485E6004793E034080020B242C6',734,"XMLEXTRA"
              ,"XMLDATA"),'/home/QUINE/PurchaseOrders/2002/Apr',9999)=1)
   7 - access("H"."PARENT_OID"=SYS_OP_ATG(VALUE(KOKBF$),3,4,2) AND
              "H"."NAME"=SYS_OP_ATG(VALUE(KOKBF$),2,3,2))
   8 - access("R2"."SYS_NC_OID$"=SYS_OP_ATG(VALUE(KOKBF$),3,4,2))

25 rows selected.
```

22

How to Configure Oracle XML DB Repository

This chapter describes how to configure Oracle XML DB Repository. It contains these topics:

- Resource Configuration Files Configure a Resource
- Configuring a Resource
- Common Configuration Parameters

This chapter describes general configuration that applies to all repository resources. It does not describe configuration parameters for specific uses of resources. In particular, it does not describe configuration parameters for handling events or managing XLink and XInclude processing.

See Also:

- "Oracle XML DB Protocol Server Configuration Management" on page 28-3
- "Configuration of Repository Events" on page 30-8
- "Configuration of Repository Resources for XLink and XInclude" on page 23-9
- "XDBResource.xsd: XML Schema for Oracle XML DB Resources" on page A-1
- "XDBResConfig.xsd: XML Schema for Resource Configuration" on page A-10
- "Package DBMS_XDB_ADMIN" on page 35-13, for information about using a dedicated tablespace for the repository

Resource Configuration Files Configure a Resource

Resource configuration is a general mechanism that you can use for events, mime-type mappings, servlet parameters, XLink and XInclude processing, default ACL specifications, and more.

You configure a Oracle XML DB Repository resource for any purpose by associating it with a resource configuration file, which defines configurable parameters for the resource. A **resource configuration file** is an XML file that conforms to the XML schema `XDBResConfig.xsd`, which is accessible in Oracle XML DB Repository at path `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResConfig.xsd`. This XML schema is defined by Oracle XML DB, and you cannot alter it.

A resource configuration file is itself a resource in Oracle XML DB Repository. You use PL/SQL procedure `DBMS_RESCONFIG.addResConfig` to map a resource to the file that configures it. A single resource configuration file can alternatively apply to all resources in the repository. In that case, you use PL/SQL procedure `DBMS_RESCONFIG.addRepositoryResConfig` to map it to the repository as a whole.

The same resource configuration file can be used to configure more than one resource, if appropriate. Oracle recommends that you have resources share a configuration file this way whenever the same configuration makes sense. This can improve run-time performance. It also simplifies repository management by letting you update a configuration in a single place and have the change affect multiple resources.

Avoid creating multiple, equivalent resource configuration files, because that can impact performance negatively. If Oracle XML DB detects duplicate resource configuration files, it raises an error.

Typically, you configure a resource for use with a particular application. In order for a resource to be shared by multiple applications, it must be possible for different applications to configure it differently. You do this by creating multiple resource configuration files and mapping them to the same resource. Each resource is thus associated with a list of configurations, a **resource configuration list**. Configurations in a configuration list are processed in the list order.

The repository itself has a list of resource configuration files, for repository-wide configuration, which really means configuration of all resources in the repository. The same configuration file must not be used for both the repository itself and a specific resource. Otherwise, an error is raised. An error is also raised if the same resource configuration file appears more than once in any given resource configuration list.

Note: An error is raised if you try to create more than 125 resource configuration files for repository-wide configuration.

The resource configuration list of a new resource is based on the information in the `configuration` elements of all resource configuration files for the parent folder of the new resource. If there is no such information (no configuration file or no `defaultChildConfig` elements in the files), then the `configuration` elements of the repository resource configuration list are used. If that information is also missing, then the new resource has an empty resource configuration list.

You can view the configuration list for a particular resource by extracting element `/Resource/RCList` from column `RES` of view `RESOURCE_VIEW`, or by using PL/SQL procedure `DBMS_RESCONFIG.getResConfigPath`. You can view the configuration list for the repository as a whole by using PL/SQL procedure `DBMS_RESCONFIG.getRepositoryResConfigPath`. To modify the repository-wide configuration list, you must be granted role `XDBADMIN`.

See Also: "Configuration Element defaultChildConfig" on page 22-4

Configuring a Resource

Follow these steps to configure an Oracle XML DB Repository resource or the repository as a whole (all resources):

1. Create a resource configuration file that defines the configuration. This XML file must conform to XML schema `XDBResConfig.xsd`.

2. Add the resource configuration file to the repository as a resource in its own right: a configuration resource. You can use PL/SQL function `DBMS_XDB_REPOS.createResource` to do this.
3. Map this configuration resource to the resources that it configures, or to the repository if it applies to all resources. Use PL/SQL procedure `DBMS_RESCONFIG.addResConfig` or `DBMS_RESCONFIG.appendResConfig` to map an individual resource. Use `DBMS_RESCONFIG.addRepositoryResConfig` to map the repository as a whole.
4. Commit.

> **Note:** Before performing any operation that uses a resource configuration file, you must perform a `COMMIT` operation. Until you do that, an ORA-22881 "dangling REF" error is raised whenever you use the configuration file.

PL/SQL package `DBMS_RESCONFIG` provides additional procedures to delete a configuration from a configuration list, obtain a list of paths to configurations in a configuration list, and more.

> **Note:** If you delete a resource configuration file that is referenced by another resource, a dangling `REF` error is raised whenever an attempt is made to access the configured resource.

See Also:

- Example 22–1 for an example of a simple resource configuration file
- "Configuration of Repository Events" on page 30-8 for complete examples of configuring resources
- "XDBResConfig.xsd: XML Schema for Resource Configuration" on page A-10
- *Oracle Database PL/SQL Packages and Types Reference* for information about package `DBMS_RESCONFIG`

Common Configuration Parameters

This section describes commonly used configuration parameters, that is, elements in a configuration file. Parameters specific to particular types of configuration are described elsewhere.

Configuration Element ResConfig

The top-level element of a resource configuration file is `ResConfig`. Besides `namespace` and `schemaLocation` attributes, it can contain an optional `enable` attribute. Set the value of attribute `enable` to `false` to disable the resource configuration file, so that it has no effect on the resources mapped to it. This can be useful for debugging or disabling an application. The default value of `enable`, used if the attribute is not present, is `true`.

Configuration Element defaultChildConfig

This configuration element applies to folders only. It holds configuration information that you want to be applied to all child resources in the folder. Element `defaultChildConfig` has one or more `configuration` child elements, each of which defines a possible configuration for resources in the folder.

A `configuration` element has the following child elements:

- `pre-condition` (optional) – This element specifies a condition that must be met before the resource configuration identified by the `path` element (see next) can be used as the default configuration. If element `pre-condition` is absent, then the resource configuration file targeted by `path` applies to all resources in the folder. That is, the precondition is treated as true.

  A `pre-condition` element has an optional `existsNode` child element. An `existsNode` element has a required `XPath` child element and an optional `namespace` child element, both strings. These define an XPath 1.0 expression and a namespace, respectively, that are used to check the existence of a resource. If that resource exists, then the precondition is satisfied, so the resource configuration file identified by `path` is used as a default resource configuration file for all child resources in the folder. The first component of the `XPath` element must be `Resource`.

  Note: A complex XPath expression for element `XPath` can impact performance negatively.

  If multiple `configuration` elements have true preconditions, then each of the resource configuration files identified by their associated `path` elements applies to all of the resources in the folder.

- `path` (required) – This element specifies an absolute repository path to a resource configuration file that is to be used as the default configuration for a new resource whenever the precondition specified by element `pre-condition` is satisfied.

Typically, the value of the `path` element is a path to the current resource configuration file, that is, the file that contains the `path` element. Example 22–1 illustrates this, assuming that the resource configuration file is located at path `/cm/app_rc.xml` in the repository. In this example, the precondition is that there be a `Resource` node whose content is of type `xml`. When that precondition is met, the resource configuration file in Example 22–1 applies to all resources in same folder as the configuration file (`/cm/app_rc.xml`).

Example 22–1 Resource Configuration File

```
<ResConfig xmlns="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
           xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
           xsi:schemaLocation="http://xmlns.oracle.com/xdb/XDBResConfig.xsd
                               http://xmlns.oracle.com/xdb/XDBResConfig.xsd">
  <defaultChildConfig>
    <configuration>
      <pre-condition>
        <existsNode>
          <XPath>/Resource[ContentType="xml"]</XPath>
        </existsNode>
      </pre-condition>
      <path>/cm/app_rc.xml<path>
    </configuration>
```

```
  </defaultChildConfig>
</ResConfig>
```

Configuration Element applicationData

You use element `applicationData` to store application-specific data. An application typically passes this data to an event handler when the handler is run. You can use any XML content that you want inside element `applicationData`. An event handler uses PL/SQL function `DBMS_XEVENT.getApplicationData` or Java function `oracle.xdb.XMLType.getApplicationData` to access the data in the `applicationData` of the resource configuration file for the event listener.

Example 22–2 shows an `applicationData` element for use with an Oracle Spatial and Graph application.

Example 22–2 applicationData Element

```
<applicationData>
  <spatial:data xmlns:spatial="http://oracle/cartridge/spatial.xsd">
    <spatial:xpos>5</spatial:xpos>
    <spatial:ypos>10</spatial:ypos>
  </spatial:data>
</applicationData>
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL function `DBMS_XEVENT.getApplicationData`
- *Oracle Database XML Java API Reference*, class `XDBRepositoryEvent` for information about Java function `oracle.xdb.XMLType.getApplicationData`
- Example 30–1, "Resource Configuration File for Java Event Listeners with Preconditions" on page 30-9 for an example of a resource configuration file for event listeners

23

How To Use XLink and XInclude with Oracle XML DB

This chapter describes how to use XLink and XInclude with resources in Oracle XML DB Repository. It contains these topics:

Overview of XLink and XInclude

A document-oriented, or **content-management**, application often tracks relationships, between documents, and those relationships are often represented and manipulated as links of various kinds. Such links can affect application behavior in various ways, including affecting the document content and the response to user operations such as mouse clicks.

W3C has two recommendations that are pertinent in this context, for documents that are managed in XML repositories:

- **XLink –** Defines various types of links between resources. These links can model arbitrary relationships between documents. Those documents can reside inside or outside the repository.
- **XInclude –** Defines ways to include the content of multiple XML documents or fragments in a single infoset. This provides for compound documents, which model inclusion relationships. **Compound documents** are documents that contain other documents. More precisely, they are file resources that include documents or document fragments. The included objects can be file resources in the same repository or documents or fragments outside the repository.

Each of these standards is very general, and it is not limited to modeling relationships between XML documents. There is no requirement that the documents linked using XLink or included in an XML document using XInclude be XML documents.

Using XLink and XInclude to represent document relationships provides flexibility for applications, facilitates reuse of component documents, and enables their fine-grained manipulation (access control, versioning, metadata, and so on). Whereas using XML data structure (an ancestor–descendents hierarchy) to model relationships requires those relationships to be relatively fixed, using XLink and XInclude to model relationships can easily allow for change in those relationships.

Note: For XML schema-based documents to be able to use XLink and XInclude attributes, the XML schema must either explicitly declare those attributes or allow any attributes.

See Also:

- `http://www.w3.org/TR/xlink` for information about the XLink standard
- `http://www.w3.org/TR/xinclude` for information about the XInclude standard

XLink and XInclude Link Types

This section describes XLink and XInclude link types and the relation between these and Oracle XML DB Repository links. XLink links are more general than repository links. XLink links can be simple or extended. Oracle XML DB supports only simple XLink links, not extended links.

XLink and XInclude Links Model Document Relationships

XLink and XInclude links model arbitrary relationships among documents. The meaning and behavior of a relationship are determined by the applications that use the link. They are not inherent in the link itself. XLink and XInclude links can be mapped to Oracle XML DB **document links**. When document links target Oracle XML DB Repository resources, they can (according to a configuration option) be hard or weak links. In this, they are similar to repository links in that context. Repository links can be navigated using file system-related protocols such as FTP and HTTP. Document links cannot, but they can be navigated using the XPath 2.0 function `fn:doc`.

See Also: "Hard Links and Weak Links" on page 21-10

XLink and XInclude Link Types

XLink and XInclude can provide links to other documents. In the case of XInclude, attributes `href` and `xpointer` are used to specify the target document.

Xlink links can be simple or extended. **Simple** links are unidirectional, from a source to a target. **Extended** links (sometimes called **complex**) can model relationships between multiple documents, with different directionalities. Both simple and extended links can include link metadata. XLink links are represented in XML data using various attributes of the namespace `http://www.w3.org/1999/xlink`, which has the predefined prefix `xlink`. Simple links are represented in XML data using attribute `type` with value `simple`, that is, `xlink:type = "simple"`. Extended Xlink links are represented using `xlink:type = "extended"`.

Third-party extended Xlink links are not contained in any of the documents whose relationships they model. Third-party links can thus be used to relate documents, such as binary files, that, themselves, have no way of representing a link.

The source end of a simple Xlink link (that is, the document containing the link) must be an XML document. The target end of a simple link can be any document. There are no such restrictions for extended links. Example 23–3 shows examples of simple links. The link targets are represented using attribute `xlink:href`.

XInclude: Compound Documents

XInclude is the W3C recommendation for the syntax and processing model for merging the infosets of multiple XML documents into a single infoset. Element `xi:include` is used to include another document, specifying its URI as the value of an `href` attribute. Element `xi:include` can be nested, so that an included document can itself include other documents.

(However, an inclusion cycle raises an error in Oracle XML DB. The resources are created, but an error is raised when the inclusions are expanded.)

XInclude thus provides for *compound* documents: repository file resources that include other XML documents or fragments. The included objects can be file resources in the same repository or documents or fragments outside the repository.

A book might be an example of a typical compound document, as managed by a content-management system. Each book includes chapter documents, which can each be managed as separate objects, with their own URLs. A chapter document can have its own metadata and access control, and it can be versioned. A book can include (reference) a specific version of a chapter document. The same chapter document can be included in multiple book documents, for reuse. Because inclusion is modeled using XInclude, content management is simplified. It is easy, for example, to replace one chapter in a book by another.

Example 23–1 illustrates an XML `Book` element that includes four documents. One of those documents, `part1.xml`, is also shown. Document `part1.xml` includes other documents, representing chapters.

Example 23–1 XInclude Used in a Book Document to Include Parts and Chapters

The top-level document representing a book contains element `Book`.

```
<Book xmlns:xi="http://www.w3.org/2001/XInclude">
  <xi:include href=toc.xml"/>
  <xi:include href=part1.xml"/>
  <xi:include href=part2.xml"/>
  <xi:include href=index.xml"/>
</Book>
```

A major book part, file (resource) `part2.xml`, contains a `Part` element, which includes multiple chapter documents.

```
<?xml version="1.0"?>
<Part xmlns:xi="http://www.w3.org/2001/XInclude">
  <xi:include href="chapter5.xml"/>
  <xi:include href="chapter6.xml"/>
  <xi:include href="chapter8.xml"/>
  <xi:include href="chapter9.xml"/>
</Part>
```

These are some additional features of XInclude:

- Inclusion of plain text – You can include unparsed, non-XML text using attribute `parse` with a value of `text`: `parse = "text"`.

- Inclusion of XML fragments – You can use an `xpointer` attribute in an `xi:include` element to specify an XML fragment to include, instead of an entire document.
- Fallback processing – In case of error, such as inability to access the URI of an included document, an `xi:include` syntax error, or an `xpointer` reference that returns null, XInclude performs the treatment specified by element `xi:fallback`. This generally specifies an alternative element to be included. The alternative element can itself use `xi:include` to include other documents.

Oracle XML DB Support for XLink

Oracle XML DB supports only simple XLink links, not extended XLink links.

When an XML document containing XLink attributes is added to Oracle XML DB Repository, either as resource content or as user-defined resource metadata, special processing can occur, depending on how the repository or individual repository resources are configured. Element `XLinkConfig` of the resource configuration document, `XDBResConfig.xsd`, determines this behavior. In particular, you can configure resources so that XLink links are ignored, or so that they are mapped to Oracle XML DB document links. In the latter case, configuration can specify that the document links are to be hard or weak. Hard and weak document links have the same properties as hard and weak repository links.

The privileges needed to create or update document links are the same as those needed to create or update repository links. Even partially updating a document requires the same privileges needed to delete the entire document and reinsert it. In particular, even if you update just one document link you must have delete and insert privileges for *each* of the documents linked by the document containing the link.

If configuration maps XLink links to document links, then, whenever a document containing XLink links is added to the repository, the XLink information is extracted and stored in a system link table. Link target (destination) locations are replaced by direct paths that are based on the resource OIDs. Configuration can also specify whether OID paths are to be replaced by named paths (URLs) upon document retrieval. Using OID paths instead of named paths generally offers a performance advantage when links are processed, including when resource contents are retrieved.

You can use XLink within resource content, but not within resource metadata.

See Also:

- "Use DOCUMENT_LINKS View to Examine XLink and XInclude Links" on page 23-7
- Chapter 29, "User-Defined Repository Metadata"
- "Hard Links and Weak Links" on page 21-10
- "Configuration of Repository Resources for XLink and XInclude" on page 23-9
- "XDBResConfig.xsd: XML Schema for Resource Configuration" on page A-10

Oracle XML DB Support for XInclude

Oracle XML DB supports XInclude 1.0 as the standard mechanism for managing compound documents. It does not support attribute `xpointer` and the inclusion of document fragments, however. Only complete documents can be included (using attribute `href`).

You can use XInclude to create XML documents that include existing content. You can also configure the implicit decomposition of non-schema-based XML documents, creating a set of repository resources that contain XInclude inclusion references.

The content of included documents must be XML data or plain text (with attribute `parse = "text"`). You cannot include binary content directly using XInclude, but you can use XLink to link to binary content.

You can use XInclude within resource content, but not within resource metadata.

> **See Also:** "Use DOCUMENT_LINKS View to Examine XLink and XInclude Links" on page 23-7

Expanding Compound-Document Inclusions

When you retrieve a compound document from Oracle XML DB Repository, you have a choice:

- Retrieve it as is, with the `xi:include` elements remaining as such. This is the default behavior.
- Retrieve it after replacing the `xi:include` elements with their targets, recursively, that is, after expansion of all inclusions. An error is raised if any `xi:include` element cannot be resolved.

To retrieve the document in expanded form, use PL/SQL constructor `XDBURIType`, passing a value of `'1'` or `'3'` as the second argument (flags). Example 23–2 illustrates this. These are the possible values for the second argument of constructor `XDBURIType`:

- `1` – Expand all XInclude inclusions before returning the result. If any such inclusion cannot be resolved according to the XInclude standard fallback semantics, then raise an error.
- `2` – Suppress all errors that might occur during document retrieval. This includes dangling `href` pointers.
- `3` – Same as `1` and `2` together.

Example 23–2 retrieves all documents that are under repository folder `public/bookdir`, expanding each inclusion:

Example 23–2 Expanding Document Inclusions Using XDBURIType

```
SELECT XDBURIType(ANY_PATH, '1').getXML() FROM RESOURCE_VIEW
  WHERE under_path(RES, '/public/bookdir') = 1;

XDBURITYPE(ANY_PATH,'1').GETXML()
---------------------------------
<Book>
  <Title>A book</Title>
  <Chapter id="1">
    <Title>Introduction</Title>
    <Body>
      <Para>blah blah</Para>
      <Para>foo bar</Para>
    </Body>
  </Chapter>
  <Chapter id="2">
    <Title>Conclusion</Title>
    <Body>
      <Para>xyz xyz</Para>
      <Para>abc abc</Para>
```

```
    </Body>
  </Chapter>
</Book>

<Chapter id="1">
  <Title>Introduction</Title>
  <Body>
    <Para>blah blah</Para>
    <Para>foo bar</Para>
  </Body>
</Chapter>

<Chapter id="2">
  <Title>Conclusion</Title>
  <Body>
    <Para>xyz xyz</Para>
    <Para>abc abc</Para>
  </Body>
</Chapter>

3 rows selected.
```

(The result shown here corresponds to the resource `bookfile.xml` shown in Example 23–8, together with its included resources, `chap1.xml` and `chap2.xml`.)

See Also:

- "Compound Document Versioning, Locking, and Access Control" on page 23-6 for information about access control during expansion
- *Oracle Database PL/SQL Packages and Types Reference* for more information about `XDBURIType`

Validation of Compound Documents

You validate a compound document the way you would any XML document. However, you can choose to validate it in either form: with `xi:include` elements as is or after replacing them with their targets.

You can also choose to use one XML schema to validate the unexpanded form, and another to validate the expanded form. For example, you might use one XML schema to validate without first expanding, in order to set up storage structures, and then use another XML schema to validate the expanded document after it is stored.

Update of a Compound Document

You can update a compound document just as you would update any resource. This replaces the resource with a new value. It thus corresponds to a resource deletion followed by a resource insertion. This means, in particular, that any `xi:include` elements in the original resource are deleted. Any `xi:include` elements in the replacement (inserted) document are processed as usual, according to the configuration defined at the time of insertion.

Compound Document Versioning, Locking, and Access Control

The components of a compound document are separate resources. They are versioned and locked independently, and their access is controlled independently.

- Document links to version-controlled resources (VCRs) always resolve to the latest version of the target resource, or the selected version within the current workspace. You can, however, explicitly refer to any specific version, by identifying the target resource by its OID-based path.
- Locking a document that contains `xi:include` elements does not also lock the included documents. Locking an included document does not also lock documents that include it.
- The access control list (ACL) on each referenced document is checked whenever you retrieve a compound document with expansion. This is done using the privileges of the current user (invoker's rights). If privileges are insufficient for any of the included documents, the expansion is canceled and an error is raised.

See Also:

- "Expanding Compound-Document Inclusions" on page 23-5
- Chapter 25, "Resource Versions" for information about VCRs
- Chapter 27, "Repository Access Control" for information about resource ACLs

Use DOCUMENT_LINKS View to Examine XLink and XInclude Links

You can query the read-only public view `DOCUMENT_LINKS` to obtain system information about document links derived from both XLink and XInclude links. The information in this view includes the following columns, for each link:

- `SOURCE_ID` – The source resource OID. `RAW(16)`.
- `TARGET_ID` – The target resource OID. `RAW(16)`.
- `TARGET_PATH` – Always `NULL`. Reserved for future use. `VARCHAR2(4000)`.
- `LINK_TYPE` – The document link type: `Hard` or `Weak`. `VARCHAR2(8)`.
- `LINK_FORM` – Whether the original link was of form `XLink` or `XInclude`. `VARCHAR2(8)`.
- `SOURCE_TYPE` – Always `Resource Content`. `VARCHAR2(17)`.

You can obtain information about a resource from this view only if one of the following conditions holds:

- The resource is a link source, and you have the privilege `read-contents` or `read-properties` on it.
- The resource is a link target, and you have the privilege `read-properties` on it.

See Also: *Oracle Database Reference* for more information on public view `DOCUMENT_LINKS`

Querying DOCUMENT_LINKS for XLink Information

Example 23–3 shows how XLink links are treated when resources are created, and how to obtain system information about document links from view `DOCUMENT_LINKS`. It assumes that the folder containing the resource has been configured to map XLink links to document hard links.

Example 23–3 Querying Document Links Mapped From XLink Links

```
DECLARE
```

```
  b BOOLEAN;
BEGIN
  b := DBMS_XDB_REPOS.createResource(
         '/public/hardlinkdir/po101.xml',
         '<PurchaseOrder id="101" xmlns:xlink="http://www.w3.org/1999/xlink">
            <Company xlink:type="simple"
                     xlink:href="/public/hardlinkdir/oracle.xml">Oracle Corporation</Company>
            <Approver xlink:type="simple"
                      xlink:href="/public/hardlinkdir/quine.xml">Willard Quine</Approver>
          </PurchaseOrder>');

  b := DBMS_XDB_REPOS.createResource(
         '/public/hardlinkdir/po102.xml',
         '<PurchaseOrder id="102" xmlns:xlink="http://www.w3.org/1999/xlink">
            <Company xlink:type="simple"
                     xlink:href="/public/hardlinkdir/oracle.xml">Oracle Corporation</Company>
            <Approver xlink:type="simple"
                      xlink:href="/public/hardlinkdir/curry.xml">Haskell Curry</Approver>
            <ReferencePO xlink:type="simple"
                         xlink:href="/public/hardlinkdir/po101.xml"/>
          </PurchaseOrder>');
END;
/

SELECT r1.ANY_PATH source, r2.ANY_PATH target, dl.LINK_TYPE, dl.LINK_FORM
  FROM DOCUMENT_LINKS dl, RESOURCE_VIEW r1, RESOURCE_VIEW r2
  WHERE dl.SOURCE_ID = r1.RESID and dl.TARGET_ID = r2.RESID;

SOURCE                         TARGET                         LINK_TYPE LINK_FORM
------------------------------ ------------------------------ --------- ---------
/public/hardlinkdir/po101.xml /public/hardlinkdir/oracle.xml Hard      XLink
/public/hardlinkdir/po101.xml /public/hardlinkdir/quine.xml  Hard      XLink
/public/hardlinkdir/po102.xml /public/hardlinkdir/oracle.xml Hard      XLink
/public/hardlinkdir/po102.xml /public/hardlinkdir/curry.xml  Hard      XLink
/public/hardlinkdir/po102.xml /public/hardlinkdir/po101.xml  Hard      XLink
```

> **See Also:** "Mapping XInclude Links to Hard Document Links, with OID Retrieval" on page 23-12 for an example of configuring a folder to map XLink links to hard links

Querying DOCUMENT_LINKS for XInclude Information

Example 23–4 queries view DOCUMENT_LINKS to show all document links.

Example 23–4 Querying Document Links Mapped From XInclude Links

```
DECLARE
  ret BOOLEAN;
BEGIN
  ret := DBMS_XDB_REPOS.createResource(
           '/public/hardlinkdir/book.xml',
           '<Book xmlns:xi="http://www.w3.org/2001/XInclude">
              <xi:include href="/public/hardlinkdir/toc.xml"/>
              <xi:include href="/public/hardlinkdir/part1.xml"/>
              <xi:include href="/public/hardlinkdir/part2.xml"/>
              <xi:include href="/public/hardlinkdir/index.xml"/>
            </Book>');
END;

SELECT r1.ANY_PATH source, r2.ANY_PATH target, dl.LINK_TYPE, dl.LINK_FORM
  FROM DOCUMENT_LINKS dl, RESOURCE_VIEW r1, RESOURCE_VIEW r2
  WHERE dl.SOURCE_ID = r1.RESID and dl.TARGET_ID = r2.RESID;
```

```
SOURCE                        TARGET                        LINK_TYPE LINK_FORM
------                        ------                        --------- ---------
/public/hardlinkdir/book.xml /public/hardlinkdir/toc.xml   Hard      XInclude
/public/hardlinkdir/book.xml /public/hardlinkdir/part1.xml Hard      XInclude
/public/hardlinkdir/book.xml /public/hardlinkdir/part2.xml Hard      XInclude
/public/hardlinkdir/book.xml /public/hardlinkdir/index.xml Hard      XInclude
```

Configuration of Repository Resources for XLink and XInclude

You configure XLink and XInclude treatment for Oracle XML DB Repository resources as you would configure any other treatment of repository resources—see "Configuring a Resource" on page 22-2. The rest of this section describes the resource configuration file that you use as a resource to configure XLink and XInclude processing for other resources.

A resource configuration file is an XML file that conforms to the XML schema `XDBResConfig.xsd`, which is accessible in Oracle XML DB Repository at path `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResConfig.xsd`. You use elements `XLinkConfig` and `XIncludeConfig`, children of element `ResConfig`, to configure XLink and XInclude treatment, respectively. If one of these elements is absent, then there is no treatment of the corresponding type of links.

Both `XLinkConfig` and `XIncludeConfig` can have attribute `UnresolvedLink` and child elements `LinkType` and `PathFormat`. Element `XIncludeConfig` can also have child element `ConflictRule`. If the `LinkType` element content is `None`, however, then there must be no `PathFormat` or `ConflictRule` element.

You cannot define any preconditions for `XLinkConfig` or `XIncludeConfig`. During repository resource creation, the `ResConfig` element of the parent folder determines the treatment of XLink and XInclude links for the new resource. If the parent folder has no `ResConfig` element, then the repository-wide configuration applies.

Any change to the resource configuration file applies only to documents that are created or updated after the configuration-file change. To process links in existing documents, use PL/SQL procedure `DBMS_XDB_REPOS.processLinks`, after specifying the appropriate resource configuration parameters.

See Also:

- "Manage XLink and XInclude Links Using DBMS_XDB_REPOS.processLinks" on page 23-13
- Chapter 22, "How to Configure Oracle XML DB Repository"

Configure the Treatment of Unresolved Links: Attribute UnresolvedLink

A `LinkConfig` element can have an `UnresolvedLink` attribute with a value of `Error` (default value) or `Skip`. This determines what happens if an XLink or XInclude link cannot be resolved at the time of document insertion into the repository (resource creation). `Error` means raise an error and roll back the current operation. `Skip` means skip any treatment of the XLink or XInclude link. Skipping treatment creates the resource with no corresponding document links, and sets the resource's `HasUnresolvedLinks` attribute to `true`, to indicate that the resource has unresolved links.

Using `Skip` as the value of attribute `UnresolvedLink` can be especially useful when you create a resource that contains a cycle of weak links, which would otherwise lead to unresolved-link errors during resource creation. After the resource and all of its linked

resources have been created, you can use PL/SQL procedure `DBMS_XDB_REPOS.processLinks` to process the skipped links. If all XLink and XInclude links have been resolved by this procedure, then attribute `HasUnresolvedLinks` is set to `false`.

Resource attribute `HasUnresolvedLinks` is also set to `true` for a resource that has a weak link to a resource that has been deleted. Deleting a resource thus effectively also deletes any weak links pointing to that resource. In particular, whenever the last hard link to a resource is deleted, the resource is itself deleted, and all resources that point to the deleted resource with a weak link have attribute `HasUnresolvedLinks` set to `true`.

See Also:

- "Hard Links and Weak Links" on page 21-10
- "Manage XLink and XInclude Links Using DBMS_XDB_REPOS.processLinks" on page 23-13

Configure the Type of Document Links to Create: Element LinkType

You use the `LinkType` element of a resource configuration file to specify the type of document link to be created whenever an XLink or XInclude link is encountered when a document is stored in Oracle XML DB Repository. The `LinkType` element has these possible values (element content):

- `None` (default) – Ignore XLink or XInclude links: create no corresponding document links.
- `Hard` – Map XLink or XInclude links to hard document links in repository documents.
- `Weak` – Map XLink or XInclude links to weak document links in repository documents.

See Also:

- Example 23–5
- Example 23–6

Configure the Path Format for Retrieval: Element PathFormat

You use the `PathFormat` element of a resource configuration file to specify the path format to be used when retrieving documents with `xlink:href` or `xi:include:href` attributes. The `PathFormat` element has these possible values (element content) for hard and weak document links:

- `OID` (default) – Map XLink or XInclude `href` paths to OID-based paths in repository documents—that is, use OIDs directly.
- `Named` – Map XLink or XInclude `href` paths to named paths (URLs) in repository documents. The path is computed from the internal OID when the document is retrieved, so retrieval can be slower than in the case of using OID paths directly.

See Also:

- Example 23–5
- Example 23–6

Configure Conflict-Resolution for XInclude: Element ConflictRule

You use the `ConflictRule` element of a resource configuration file to specify the conflict-resolution rules to use if the path computed for a component document is already present in Oracle XML DB Repository. The `ConflictRule` element has these possible values (element content):

- `Error` (default) – Raise an error.
- `Overwrite` – Update the document targeted by the existing repository path, replacing it with the document to be included. If the existing document is a version-controlled resource, then it must already be checked out, unless it is autoversioned. Otherwise, an error is raised.
- `Syspath` – Change the path to the included document to a new, system-defined path.

> **See Also:** Chapter 25, "Resource Versions" for information about version-controlled resources

Configure the Decomposition of Documents Using XInclude: Element SectionConfig

You use the `SectionConfig` element of a resource configuration file to specify how non-schema-based XML documents are to be decomposed when added to Oracle XML DB Repository, to create a set of resources that contain XInclude inclusion references. You use simple XPath expressions in the resource configuration file to identify which parts of a document to map to separate resources, and which resources to map them to.

Element `SectionConfig` contains one or more `Section` elements, each of which contains the following child elements:

- `sectionPath` – Simple XPath 1.0 expression that identifies a section root. This must use only child and descendant axes, and it must not use wildcards.
- `documentPath` (optional) – Simple XPath 1.0 expression that is evaluated to identify the resources to be created from decomposing the document according to `sectionPath`. The XPath expression must use only child, descendant, and attribute axes.
- `namespace` (optional) – Namespace in effect for `sectionPath` and `documentPath`.

Element `Section` also has a `type` attribute that specifies the type of section to be created. Value `Document` means create a document. The default value, `None`, means do not create anything. Using `None` is equivalent to removing the `SectionConfig` element. You can thus set the `type` attribute to `None` to disable a `SectionConfig` element temporarily, without removing it, and then set it back to `Document` to enable it again.

If an element in the document being added to the repository matches more than one `sectionPath` value, only the first such expression (in document order) is used.

If no `documentPath` element is present, then the resource created has a system-defined name, and is put into the folder specified for the original document.

> **See Also:**
>
> - Example 23–7, "Configuring XInclude Document Decomposition" on page 23-12
> - Example 23–8, "Repository Document, Showing Generated xi:include Elements" on page 23-13

XLink and XInclude Configuration Examples

Example 23–5 shows a configuration-file section that configures XInclude treatment, mapping XInclude attributes to Oracle XML DB Repository hard document links. Repository paths in retrieved resources are configured to be based on resource OIDs.

Example 23–5 Mapping XInclude Links to Hard Document Links, with OID Retrieval

```
<ResConfig>
  . . .
  <XIncludeConfig UnresolvedLink="Skip">
    <LinkType>Hard</LinkType>
    <PathFormat>OID</PathFormat>
  </XIncludeConfig>
  . . .
</ResConfig>
```

Example 23–6 shows an `XLinkConfig` section that maps XLink links to weak document links in the repository. In this case, retrieval of a document uses named paths (URLs).

Example 23–6 Mapping XLInk Links to Weak Links, with Named-Path Retrieval

```
<ResConfig>
  . . .
  <XLinkConfig UnresolvedLink="Skip">
    <LinkType>Weak</LinkType>
    <PathFormat>Named</PathFormat>
  </XLinkConfig>
  . . .
</ResConfig>
```

Example 23–7 shows a `SectionConfig` section that specifies that each `Chapter` element in an input document is to become a separate repository file, when the input document is added to Oracle XML DB Repository. The repository path for the resulting file is specified using configuration element `documentPath`, and this path is relative to the location of the resource configuration file of Example 23–6.

Example 23–7 Configuring XInclude Document Decomposition

```
<ResConfig>
  . . .
  <SectionConfig>
    <Section type = "Document">
      <sectionPath>//Chapter</sectionPath>
      <documentPath>concat("chap", @id, ".xml")</documentPath>
    </Section>
  </SectionConfig>
  . . .
</ResConfig>
```

The XPath expression here uses XPath function `concat` to concatenate the following strings to produce the resulting repository path to use:

- `chap` – (prefix) `chap`.
- The value of attribute `id` of element `Chapter` in the input document.
- `.xml` as a file extension.

For example, a repository path of `chap27.xml` would result from an input document with a `Chapter` element that has an `id` attribute with value `27`:

```
<Chapter id="27"> ... </Chapter>
```

If the configuration document of Example 23–6 and the book document that contains the `XInclude` elements are in repository folder `/public/bookdir`, then the individual chapter files generated from `XInclude` decomposition are in files `/public/bookdir/chapN.xml`, where the values of *N* are the values of the `id` attributes of `Chapter` elements.

The book document that is added to the repository is derived from the input book document. The embedded `Chapter` elements in the input book document are replaced by `xi:include` elements that reference the generated chapter documents—Example 23–8 illustrates this.

Example 23–8 Repository Document, Showing Generated xi:include Elements

```
SELECT XDBURIType('/public/bookdir/bookfile.xml').getclob() FROM DUAL;

XDBURITYPE('/PUBLIC/BOOKDIR/BOOKFILE.XML').GETCLOB()
--------------------------------------------------------------------------------
<Book>
  <Title>A book</Title>
  <xi:include xmlns:xi="http://www.w3.org/2001/XInclude" href="/public/bookdir/chap1.xml"/>
  <xi:include xmlns:xi="http://www.w3.org/2001/XInclude" href="/public/bookdir/chap2.xml"/>
</Book>
```

See Also:

- Chapter 22, "How to Configure Oracle XML DB Repository"
- XDBResConfig.xsd: XML Schema for Resource Configuration
- "Configure the Decomposition of Documents Using XInclude: Element SectionConfig" on page 23-11

Manage XLink and XInclude Links Using DBMS_XDB_REPOS.processLinks

You can use PL/SQL procedure `DBMS_XDB_REPOS.processLinks` to manually process all XLink and XInclude links in a single document or in all documents of a folder. Pass `RECURSIVE` as the mode argument to this procedure, if you want to process all hard-linked subfolders recursively. All XLink and XInclude links are processed according to the corresponding configuration parameters. If any of the links within a resource cannot be resolved, the resource's `HasUnresolvedLinks` attribute is set to `true`, to indicate that the resource has unresolved links. The default value of attribute `HasUnresolvedLinks` is `false`.

See Also: "Configure the Treatment of Unresolved Links: Attribute UnresolvedLink" on page 23-9

24

Repository Access Using RESOURCE_VIEW and PATH_VIEW

This chapter describes the predefined public views, RESOURCE_VIEW and PATH_VIEW, that provide access to Oracle XML DB repository data. It discusses Oracle SQL functions under_path and equals_path, which query resources based on their path names, and functions path and depth, which return resource path names and depths, respectively.

This chapter contains these topics:

- Overview of Oracle XML DB RESOURCE_VIEW and PATH_VIEW
- RESOURCE_VIEW and PATH_VIEW SQL Functions
- Accessing Repository Data Paths, Resources and Links: Examples
- Deleting Repository Resources: Examples
- Updating Repository Resources: Examples
- Working with Multiple Oracle XML DB Resources
- Performance Tuning of Oracle XML DB Repository Operations
- Searching for Resources Using Oracle Text

See Also:

- *Oracle Database Reference* for more information about view PATH_VIEW
- *Oracle Database Reference* for more information about view RESOURCE_VIEW

Overview of Oracle XML DB RESOURCE_VIEW and PATH_VIEW

Figure 24–1 shows how Oracle XML DB RESOURCE_VIEW and PATH_VIEW provide a mechanism for using SQL to access data stored in Oracle XML DB Repository. Data stored in the repository using protocols such as FTP and WebDAV, or using application program interfaces (APIs), can be accessed in SQL using RESOURCE_VIEW values and PATH_VIEW values.

RESOURCE_VIEW consists of a resource, itself an XMLType, that contains the name of the resource that can be queried, its ACLs, and its properties, static or extensible.

- If the content comprising the resource is XML data stored somewhere in an XMLType table or view, then the RESOURCE_VIEW points to the XMLType row that stores the content.

- If the content is not XML data, then the RESOURCE_VIEW stores it as a LOB.

> **Note:** As of Oracle Database Release 11.2.0.1.0, repository content stored in line as a LOB uses SecureFiles LOB storage. Prior to that, it used BasicFiles LOB storage.

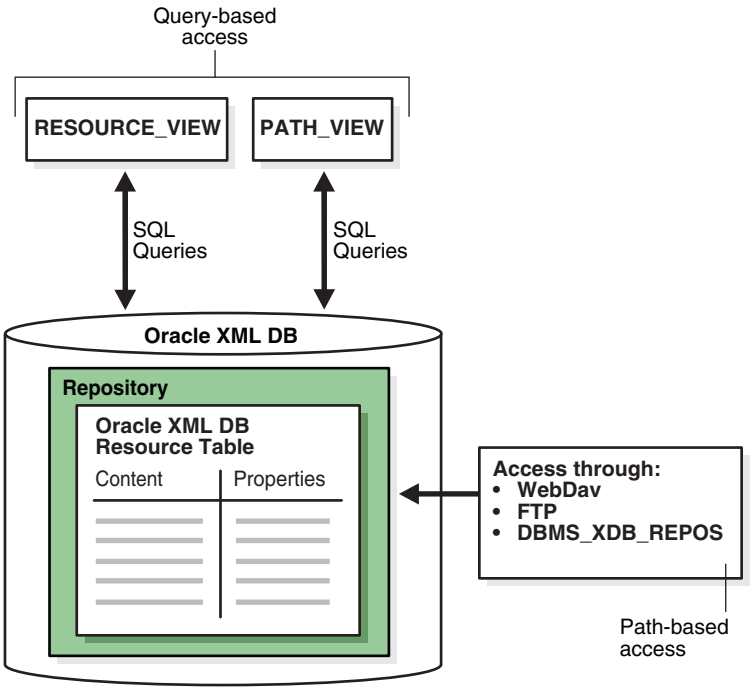
Parent-child relationships between folders (necessary to construct the hierarchy) are maintained and traversed efficiently using the hierarchical repository index. Text indexes are available to search the properties of a resource, and internal B-tree indexes over Names and ACLs speed up access to these attributes of the Resource XMLType.

RESOURCE_VIEW and PATH_VIEW, along with PL/SQL package DBMS_XDB_REPOS, provide all query-based access to Oracle XML DB and DML functionality that is available through the API.

The base table for RESOURCE_VIEW is XDB.XDB$RESOURCE. Access this table only using RESOURCE_VIEW or PL/SQL package DBMS_XDB_REPOS.

See Also: Chapter 3, "Overview of How To Use Oracle XML DB"

Figure 24–1 Accessing Repository Resources Using RESOURCE_VIEW and PATH_VIEW



> **Note:** Neither RESOURCE_VIEW nor PATH_VIEW contains the *root* folder (/) resource. All other repository resources are included.

RESOURCE_VIEW Definition and Structure

The RESOURCE_VIEW contains one row for each resource in Oracle XML DB Repository (except for the root folder resource). Table 24–1 describes its structure.

Table 24–1 Structure of RESOURCE_VIEW

Column	Data Type	Description
RES	XMLType	A resource in the repository (except for the root folder resource)
ANY_PATH	VARCHAR2	An (absolute) path to the resource
RESID	RAW	Resource OID, which is a unique handle to the resource

PATH_VIEW Definition and Structure

The PATH_VIEW contains one row for each unique path to access a resource in Oracle XML DB Repository (except for the root folder resource). Each resource may have multiple paths, also called **links**. Table 24–2 describes its structure.

Table 24–2 Structure of PATH_VIEW

Column	Data Type	Description
PATH	VARCHAR2	An (absolute) path to repository resource RES
RES	XMLType	The resource referred to by column PATH
LINK	XMLType	Link property
RESID	RAW	Resource OID

Figure 24–2 illustrates the structure of RESOURCE_VIEW and PATH_VIEW.

The path in the RESOURCE_VIEW is an arbitrary one and one of the accessible paths that can be used to access that resource. Oracle SQL function under_path lets applications search for resources that are contained (recursively) within a particular folder, get the resource depth, and so on. Each row in the PATH_VIEW and RESOURCE_VIEW columns is of XMLType. DML on repository views can be used to insert, rename, delete, and update resource properties and contents. Programmatic APIs must be used for some operations, such as creating links to existing resources.

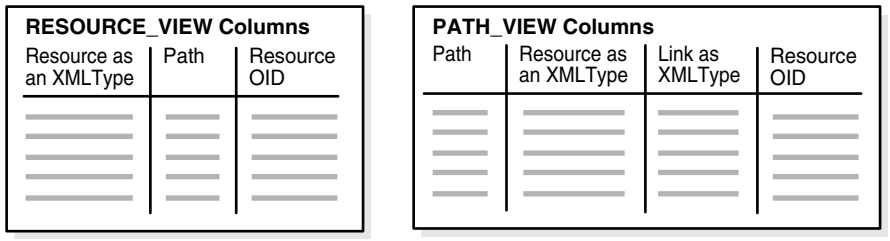
Paths in the ANY_PATH column of the RESOURCE_VIEW and the PATH column in the PATH_VIEW are *absolute* paths: they start at the root.

> **Note:** Test resource paths for equality using Oracle SQL function equals_path: equals_path('/my/path') = 1. Do *not* test ANY_PATH for equality against an absolute path: ANY_PATH = '/my/path'.

Paths returned by the path function are *relative* paths under the path name specified by function under_path. For example, if there are two resources referenced by path names /a/b/c and /a/d, respectively, then a path expression that retrieves paths under folder /a returns relative paths b/c and d.

When there are multiple hard links to the same resource, only paths under the path name specified by function under_path are returned. If /a/b/c, /a/b/d, and /a/e are all links to the same resource, then a query on PATH_VIEW that retrieves all of the paths under /a/b returns only /a/b/c and /a/b/d, not /a/e.

Figure 24–2 RESOURCE_VIEW and PATH_VIEW Structure



The Difference Between RESOURCE_VIEW and PATH_VIEW

Views `RESOURCE_VIEW` and `PATH_VIEW` differ as follows:

- `PATH_VIEW` displays *all* the path names to a particular resource. `RESOURCE_VIEW` displays *one* of the possible path names to the resource
- `PATH_VIEW` also displays the properties of the link

Figure 24–3 illustrates this difference between `RESOURCE_VIEW` and `PATH_VIEW`.

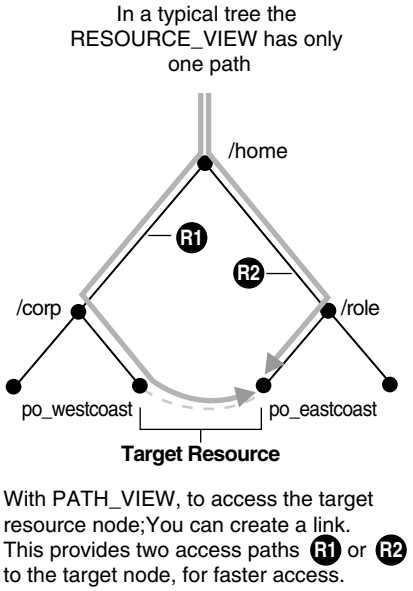
Because many Internet applications only need one URL to access a resource, `RESOURCE_VIEW` is widely applicable.

`PATH_VIEW` contains the *link* properties and resource properties, whereas the `RESOURCE_VIEW` only contains resource properties.

Whenever possible, use `RESOURCE_VIEW`, not `PATH_VIEW`, for better performance. Because it handles the information for multiple paths, `PATH_VIEW` access can be slower. If you use `RESOURCE_VIEW`, then the database can determine that only one path is needed, and the index can do less work to determine all the possible paths.

Note: When using the `RESOURCE_VIEW`, if you specify a path with functions `under_path` or `equals_path`, then they find the resource regardless of whether or not that path is the arbitrary one chosen to normally appear with that resource using `RESOURCE_VIEW`.

Figure 24–3 RESOURCE_VIEW and PATH_VIEW Explained



RESOURCE_VIEW Example:
select path(1) from RESOURCE_VIEW where under_path(res, '/sys',1);
displays one path to the resource:
/home/corp/po_westcoast

PATH_VIEW Example:
select path from PATH_VIEW;
displays all pathnames to the resource:
/home/corp/po_westcoast
/home/role/po_eastcoast

Operations You Can Perform Using UNDER_PATH and EQUALS_PATH

You can perform the following operations using Oracle SQL functions `under_path` and `equals_path`:

- Given a path name:
  - Get a resource or its OID
  - List the directory given by the path name
  - Create a resource
  - Delete a resource
  - Update a resource
- Given a condition that uses `under_path` or other SQL functions:
  - Update resources
  - Delete resources
  - Get resources or their OID

RESOURCE_VIEW and PATH_VIEW SQL Functions

This section describes Oracle SQL functions that are applicable to `RESOURCE_VIEW` and `PATH_VIEW`.

UNDER_PATH SQL Function

Oracle SQL function `under_path` uses the hierarchical index of Oracle XML DB Repository to return the paths to all hard links under a particular path. This index is designed to speed access when traversing a path (the most common usage).

If the other parts of the query predicate are very selective, however, then a functional implementation of `under_path` can be chosen that walks back up the repository. This can be more efficient, because fewer links must be traversed. Figure 24–4 shows the

under_path syntax.

Figure 24–4 UNDER_PATH Syntax

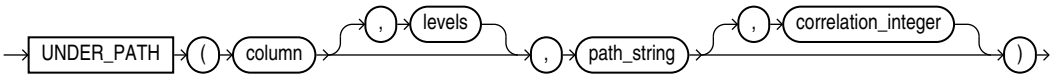


Table 24–3 details the signature of Oracle SQL function under_path.

Table 24–3 UNDER_PATH SQL Function Signature

Syntax	Description
under_path(*resource_column*, *pathname*);	Determines whether a resource is under a specified path. Parameters: ■ *resource_column* –The column name or column alias of the RESOURCE column in the PATH_VIEW or RESOURCE_VIEW. ■ *pathname* – The path name to resolve.
under_path(*resource_column*, *depth*, *pathname*);	Determines whether a resource is under a specified path, with a depth argument to restrict the number of levels to search. Parameters: ■ *resource_column* – The column name or column alias of the RESOURCE column in the PATH_VIEW or RESOURCE_VIEW. ■ depth – The maximum depth to search. A nonnegative integer. ■ *pathname* – The path name to resolve.
under_path(*resource_column*, *pathname*, *correlation*);	Determines if a resource is under a specified path, with a correlation argument for related SQL functions. Parameters: ■ *resource_column* – The column name or column alias of the RESOURCE column in the PATH_VIEW or RESOURCE_VIEW. ■ *pathname* – The path name to resolve. ■ *correlation* – An integer that can be used to correlate under_path with related SQL functions (path and depth).
under_path(*resource_column*, *depth*, *pathname*, *correlation*);	Determines if a resource is under a specified path with a depth argument to restrict the number of levels to search, and with a correlation argument for related SQL functions. Parameters: ■ *resource_column* – The column name or column alias of the RESOURCE column in the PATH_VIEW or RESOURCE_VIEW. ■ *depth* – The maximum depth to search. A nonnegative integer. ■ *pathname* – The path name to resolve. ■ *correlation* – An integer that can be used to correlate under_path with related SQL functions (path and depth). Note that, for a resource to be returned, only one of the accessible paths to the resource must be under the *pathname* argument. If no such path is under argument *pathname* then a NULL value is returned.

Note: Function under_path does not follow weak links, because such traversal could lead to cycles. A weak-link argument to under_path is resolved correctly, but weak links are not followed when traversing resources under that path.

EQUALS_PATH SQL Function

Oracle SQL function `equals_path` is used to find the resource with the specified path name. It is functionally equivalent to `under_path` with a depth restriction of zero.

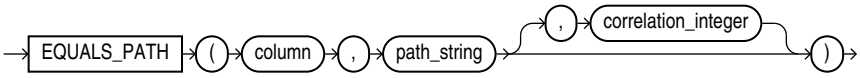
```
equals_path(resource_column, pathname);
```

where:

- `resource_column` is the column name or column alias of the `RESOURCE` column in `PATH_VIEW` or `RESOURCE_VIEW`.
- `pathname` is the (absolute) path name to resolve. This can contain components that are hard or weak resource links.

Figure 24–5 illustrates the complete `equals_path` syntax.

Figure 24–5 EQUALS_PATH Syntax



Note:

- Test resource paths for equality using Oracle SQL function `equals_path`: `equals_path('/my/path') = 1`. Do *not* test `ANY_PATH` for equality against an absolute path: `ANY_PATH = '/my/path'`.
- Use bind variables, instead of hard-coded strings, with `equals_path`.

PATH SQL Function

Oracle SQL function `path` returns the relative path name of the resource under the specified *`pathname`* argument to function `under_path` or `equal_path`. The path column in the `RESOURCE_VIEW` always contains the absolute path of the resource. The `path` syntax is:

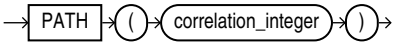
```
path(correlation);
```

where:

- *`correlation`* is an integer that can be used to correlate `path` with under_path or `equals_path`.

Figure 24–6 illustrates the syntax for function `path`.

Figure 24–6 PATH Syntax



DEPTH SQL Function

Oracle SQL function `depth` returns the folder depth of the resource under the specified starting path.

```
depth(correlation);
```

where:

correlation is an integer that can be used to correlate `depth` with `path` with under_path or `equals_path`.

Accessing Repository Data Paths, Resources and Links: Examples

The following examples illustrate how you can access paths, resources, and link properties in Oracle XML DB Repository. The first few examples use resources specified by the following paths:

```
/a/b/c
/a/b/c/d
/a/e/c
/a/e/c/d
```

Example 24–1 uses Oracle SQL function `path` to retrieve the *relative* paths under path `/a/b`.

Example 24–1 Determining Paths Under a Path: Relative

```
SELECT path(1) FROM RESOURCE_VIEW WHERE under_path(RES, '/a/b', 1) = 1;

PATH(1)
-------
c
c/d

2 rows selected.
```

Example 24–2 uses `ANY_PATH` to retrieve the *absolute* paths under path `/a/b`.

Example 24–2 Determining Paths Under a Path: Absolute

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE under_path(RES, '/a/b') = 1;

ANY_PATH
--------
/a/b/c
/a/b/c/d

2 rows selected.
```

Example 24–3 is the same as Example 24–2, except that the test is *not*-equals (`!=`) instead of equals (`=`). The query in Example 24–3 finds *all paths in the repository* that are *not* under path `/a/b`.

Example 24–3 Determining Paths Not Under a Path

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE under_path(RES, '/a/b') != 1

ANY_PATH
--------
/a
/a/b
/a/e
/a/e/c
/a/e/c/d
/home
```

```
/home/OE
/home/OE/PurchaseOrders
/home/OE/PurchaseOrders/2002
/home/OE/PurchaseOrders/2002/Apr
/home/OE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
/home/OE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336271PDT.xml
/home/OE/PurchaseOrders/2002/Apr/EABEL-20021009123336251PDT.xml
. . .
/public
/sys
/sys/acls
/sys/acls/all_all_acl.xml
/sys/acls/all_owner_acl.xml
/sys/acls/bootstrap_acl.xml
/sys/acls/ro_all_acl.xml
/sys/apps
/sys/apps/plsql
/sys/apps/plsql/xs
/sys/apps/plsql/xs/netaclrc.xml
/sys/apps/plsql/xs/netaclsc.xml
/sys/databaseSummary.xml
/sys/log
/sys/schemas
/sys/schemas/OE
/sys/schemas/OE/localhost:8080
. . .

326 rows selected.
```

Example 24–4 shows the relative paths that are under repository folders `a/b` and `/a/e`, respectively. The expression `path(1)` represents the paths that are under folder `a/b`, since it uses the same correlation number, **1**, as the expression `under_path(RES, '/a/b', 1)`, which specifies folder `a/b`. Similarly for `path(2)` and folder `/a/e`. Expression `ANY_PATH` returns the corresponding absolute paths.

Example 24–4 Determining Paths Using Multiple Correlations

```
SELECT ANY_PATH, path(1), path(2)
  FROM RESOURCE_VIEW
  WHERE under_path(RES, '/a/b', 1) = 1 OR under_path(RES, '/a/e', 2) = 1;

ANY_PATH   PATH(1)  PATH(2)
---------- -------- --------
/a/b/c     c
/a/b/c/d   c/d
/a/e/c              c
/a/e/c/d            c/d

4 rows selected.
```

Example 24–5 Relative Path Names for Three Levels of Resources

```
SELECT path(1) FROM RESOURCE_VIEW WHERE under_path(RES, 3, '/sys', 1) = 1;
```

This produces a result similar to the following.

```
PATH(1)
-------
acls
acls/all_all_acl.xml
acls/all_owner_acl.xml
```

```
acls/bootstrap_acl.xml
acls/ro_all_acl.xml
apps
apps/plsql
apps/plsql/xs
databaseSummary.xml
log
schemas
schemas/OE
schemas/OE/localhost:8080
schemas/PUBLIC
schemas/PUBLIC/www.w3.org
schemas/PUBLIC/xmlns.oracle.com

93 rows selected.
```

Example 24–6 Extracting Resource Metadata Using UNDER_PATH

```
SELECT ANY_PATH,
       XMLQuery('declare namespace ns = "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                 $r/ns:Resource' PASSING RES AS "r" RETURNING CONTENT)
  FROM RESOURCE_VIEW WHERE under_path(RES, '/sys') = 1;
```

This produces a result similar to the following:

```
ANY_PATH
--------
XMLQUERY('DECLARENAMESPACENS="HTTP://XMLNS.ORACLE.COM/XDB/XDBRESOURCE.XSD";(::)$
--------------------------------------------------------------------------------
/sys/acls
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd">
  <CreationDate>2008-06-25T13:17:45.164662</CreationDate>
  <ModificationDate>2008-06-25T13:17:47.865163</ModificationDate>
  <DisplayName>acls</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>application/octet-stream</ContentType>
  <RefCount>1</RefCount>
</Resource>

/sys/acls/all_all_acl.xml
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd">
  <CreationDate>2008-06-25T13:17:47.759806</CreationDate>
  <ModificationDate>2008-06-25T13:17:47.759806</ModificationDate>
  <DisplayName>all_all_acl.xml</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>text/xml</ContentType>
  <RefCount>1</RefCount>
</Resource>
. . .
41 rows selected.
```

Example 24–7 Using Functions PATH and DEPTH with PATH_VIEW

```
SELECT path(1) path, depth(1) depth FROM PATH_VIEW
  WHERE under_path(RES, 3, '/sys', 1) = 1;
```

This produces a result similar to the following:

```
PATH                                     DEPTH
----                                     -----
```

```
acls                                    1
acls/all_all_acl.xml                    2
acls/all_owner_acl.xml                  2
acls/bootstrap_acl.xml                  2
acls/ro_all_acl.xml                     2
apps                                    1
apps/plsql                              2
apps/plsql/xs                           3
databaseSummary.xml                     1
log                                     1
schemas                                 1
schemas/OE                              2
schemas/OE/localhost:8080               3
schemas/PUBLIC                          2
schemas/PUBLIC/www.w3.org               3
schemas/PUBLIC/xmlns.oracle.com         3
. . .
```

Example 24–8 Extracting Link and Resource Information from PATH_VIEW

```
SELECT PATH,
       XMLCast(XMLQuery(
                 'declare namespace ns =
                           "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                  $l/ns:LINK/ns:Name' PASSING LINK AS "l" RETURNING CONTENT)
                AS VARCHAR2(256)),
       XMLCast(XMLQuery(
                 'declare namespace ns =
                           "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                  $l/ns:LINK/ns:ParentName' PASSING LINK AS "l" RETURNING CONTENT)
                AS VARCHAR2(256)),
       XMLCast(XMLQuery(
                 'declare namespace ns =
                           "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                  $l/ns:LINK/ns:ChildName' PASSING LINK AS "l" RETURNING CONTENT)
                AS VARCHAR2(256)),
       XMLCast(XMLQuery(
                 'declare namespace ns =
                           "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                  $r/ns:Resource/ns:DisplayName'
                    PASSING RES AS "r" RETURNING CONTENT)
                AS VARCHAR2(128))
  FROM PATH_VIEW WHERE PATH LIKE '/sys%';
```

This produces a result similar to the following:

```
/sys/schemas/PUBLIC/www.w3.org/1999/xlink.xsd
xlink.xsd

/sys/schemas/PUBLIC/www.w3.org/1999/xlink
xlink

/sys/schemas/PUBLIC/www.w3.org/1999/csx.xlink.xsd
csx.xlink.xsd

. . .

118 rows selected.
```

Example 24–9 All Repository Paths to a Certain Depth Under a Path

```
SELECT path(1) FROM PATH_VIEW WHERE under_path(RES, 3, '/sys', 1) > 0;
```

This produces a result similar to the following:

```
PATH(1)
-------
acls
acls/all_all_acl.xml
acls/all_owner_acl.xml
acls/bootstrap_acl.xml
acls/ro_all_acl.xml
apps
apps/plsql
apps/plsql/xs
databaseSummary.xml
log
principals
principals/groups
principals/users
schemas
schemas/PUBLIC
schemas/PUBLIC/www.opengis.net
schemas/PUBLIC/www.w3.org
schemas/PUBLIC/xmlns.oracle.com
workspaces
. . .

43 rows selected.
```

Example 24–10 Locating a Repository Path Using EQUALS_PATH

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE equals_path(RES, '/sys') > 0;

ANY_PATH
--------
/sys

1 row selected.
```

Example 24–11 Retrieve RESID of a Given Resource

```
SELECT RESID FROM RESOURCE_VIEW
  WHERE XMLCast(XMLQuery(
                  'declare namespace ns =
                     "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                   $r/ns:Resource/ns:DisplayName'
                  PASSING RES AS "r" RETURNING CONTENT)
                AS VARCHAR2(128))
        = 'example';
```

This produces a result similar to the following:

```
RESID
--------------------------------
F301A10152470252E030578CB00B432B

1 row selected.
```

Example 24–12 Obtaining the Path Name of a Resource from its RESID

```
DECLARE
  resid_example RAW(16);
  path          VARCHAR2(4000);
BEGIN
  SELECT RESID INTO resid_example FROM RESOURCE_VIEW
    WHERE XMLCast(XMLQuery(
                    'declare namespace ns =
                       "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                     $r/ns:Resource/ns:DisplayName'
                    PASSING RES AS "r" RETURNING CONTENT)
                  AS VARCHAR2(128))

          = 'example';
  SELECT ANY_PATH INTO path FROM RESOURCE_VIEW WHERE RESID = resid_example;
  DBMS_OUTPUT.put_line('The path is: ' || path);
END;
/
The path is: /public/example

PL/SQL procedure successfully completed.
```

Example 24–13 Folders Under a Given Path

```
SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE under_path(RES, 1, '/sys') = 1
    AND XMLExists('declare namespace ns =
                     "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                   $r/ns:Resource[@Container = xs:boolean("true")]'
                  PASSING RES AS "r");
```

This produces a result like the following:

```
ANY_PATH
--------
/sys/acls
/sys/apps
/sys/log
/sys/schemas

4 rows selected.
```

Example 24–14 Joining RESOURCE_VIEW with an XMLType Table

```
SELECT ANY_PATH, XMLQuery('$p/PurchaseOrder/LineItems'
                          PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po, RESOURCE_VIEW rv
  WHERE ref(po)
        = XMLCast(XMLQuery('declare default element namespace
                             "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                             fn:data(/Resource/XMLRef)'
                           PASSING rv.RES RETURNING CONTENT)
                  AS REF XMLType)
    AND ROWNUM < 2;

ANY_PATH
--------------------------------------------------------------------------------
XMLQUERY('$P/PURCHASEORDER/LINEITEMS'PASSINGPO.OBJECT_VALUEAS"P"RETURNINGCONTENT
--------------------------------------------------------------------------------
/home/OE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
<LineItems>
```

```
  <LineItem ItemNumber="1">
    <Description>Salesman</Description>
    <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="2">
    <Description>Big Deal on Madonna Street</Description>
    <Part Id="37429155424" UnitPrice="29.95" Quantity="1"/>
  </LineItem>
  <LineItem ItemNumber="3">
    <Description>Hearts and Minds</Description>
    <Part Id="37429166321" UnitPrice="39.95" Quantity="1"/>
  </LineItem>

. . .

  <LineItem ItemNumber="23">
    <Description>Great Expectations</Description>
    <Part Id="37429128022" UnitPrice="39.95" Quantity="4"/>
  </LineItem>
</LineItems>

1 row selected.
```

Deleting Repository Resources: Examples

The examples in this section illustrate how to delete resources and paths.

If you delete only *leaf* resources, then you can use `DELETE FROM RESOURCE_VIEW`, as in Example 24–15.

Example 24–15 Deleting Resources

```
DELETE FROM RESOURCE_VIEW WHERE equals_path(RES, '/public/myfile') = 1';
```

For multiple links to the same resource, deleting from `RESOURCE_VIEW` deletes the resource together with *all* of its links. Deleting from `PATH_VIEW` deletes only the link with the specified path.

Example 24–16 illustrates this.

Example 24–16 Deleting Links to Resources

Suppose that `'/home/myfile1'` is a link to `'/public/myfile'`:

```
CALL DBMS_XDB_REPOS.link('/public/myfile', '/home', 'myfile1');
```

The following SQL DML statement deletes everything in Oracle XML DB Repository that is found at path `/home/myfile1` – both the link and the resource:

```
DELETE FROM RESOURCE_VIEW WHERE equals_path(RES, '/home/myfile1') = 1;
```

The following DML statement deletes *only the link* with path `/home/file1`:

```
DELETE FROM PATH_VIEW WHERE equals_path(RES, '/home/file1') = 1;
```

Deleting Nonempty Folder Resources

The `DELETE` DML operator is not allowed on a nonempty folder. If you try to delete a nonempty folder, you must first delete its contents and then delete the resulting empty folder. This rule must be applied recursively to any folders contained in the target folder.

However, the order of the paths returned from a `WHERE` clause is not guaranteed, and the `DELETE` operator does not allow an `ORDER BY` clause in its table-expression subclause. You *cannot* do the following:

```
DELETE FROM (SELECT 1 FROM RESOURCE_VIEW
               WHERE under_path(RES, '/public', 1) = 1
               ORDER BY depth(1) DESCENDING);
```

Example 24–17 illustrates how to delete a nonempty folder: folder `example` is deleted, along with its subfolder `example1`.

Example 24–17 Deleting a Nonempty Folder

```
SELECT PATH FROM PATH_VIEW WHERE under_path(RES, '/home/US1') = 1;

PATH
-------------------------
/home/US1/example
/home/US1/example/example1

2 rows selected.

DECLARE
  CURSOR c1 IS
    SELECT ANY_PATH p FROM RESOURCE_VIEW
      WHERE under_path(RES, '/home/US1', 1) = 1
        AND XMLExists('declare namespace ns =
                         "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                       $r/ns:Resource[ns:Owner="US1"]' PASSING RES AS "r")
      ORDER BY depth(1) DESC;
  del_stmt VARCHAR2(500) :=
    'DELETE FROM RESOURCE_VIEW WHERE equals_path(RES, :1)=1';
BEGIN
  FOR r1 IN c1 LOOP
    EXECUTE IMMEDIATE del_stmt USING r1.p;
  END LOOP;
END;
/

PL/SQL procedure successfully completed.

SELECT PATH FROM PATH_VIEW WHERE under_path(RES, '/home/US1') = 1;

no rows selected
```

> **Note:** As always, take care to avoid deadlocks with concurrent transactions when operating on multiple rows.

Updating Repository Resources: Examples

This section illustrates how to update resources and paths.

Example 24–18 changes the resource at path `/test/HR/example/paper`.

Example 24–18 Updating a Resource

This is the complete resource before the update operation:

```
SELECT XMLSerialize(DOCUMENT r.RES AS CLOB)
  FROM RESOURCE_VIEW r WHERE equals_path(r.RES, '/test/HR/example/paper') = 1;
```

```
XMLSERIALIZE(DOCUMENTR.RESASCLOB)
--------------------------------------------------------------------------------
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd" Hidden="false" Inv
alid="false" Container="false" CustomRslv="false" VersionHistory="false" StickyR
ef="true">
  <CreationDate>2005-04-29T16:30:01.588835</CreationDate>
  <ModificationDate>2005-04-29T16:30:01.588835</ModificationDate>
  <DisplayName>paper</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>application/octet-stream</ContentType>
  <RefCount>1</RefCount>
  <ACL>
    <acl description="Public:All privileges to PUBLIC" xmlns="http://xmlns.oracl
e.com/xdb/acl.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:sch
emaLocation="http://xmlns.oracle.com/xdb/acl.xsd                          http:
//xmlns.oracle.com/xdb/acl.xsd">
      <ace>
        <principal>PUBLIC</principal>
        <grant>true</grant>
        <privilege>
          <all/>
        </privilege>
      </ace>
    </acl>
  </ACL>
  <Owner>TESTUSER1</Owner>
  <Creator>TESTUSER1</Creator>
  <LastModifier>TESTUSER1</LastModifier>
  <SchemaElement>http://xmlns.oracle.com/xdb/XDBSchema.xsd#binary</SchemaElement
>
  <Contents>
    <binary>4F7261636C65206F7220554E4958</binary>
  </Contents>
</Resource>

1 row selected.
```

All of the XML elements shown here are resource *metadata* elements, with the exception of `Contents`, which contains the resource *content*.

This `UPDATE` statement updates (only) the `DisplayName` metadata element.

```
UPDATE RESOURCE_VIEW r
  SET r.RES =
    XMLQuery('copy $i := $p1 modify
                (for $j in $i/Resource/DisplayName
                 return replace value of node $j with $p2)
              return $i'
             PASSING r.RES AS "p1", 'My New Paper' AS "p2"
             RETURNING CONTENT)
    WHERE equals_path(r.RES, '/test/HR/example/paper') = 1;

1 row updated.

SELECT XMLSerialize(DOCUMENT r.RES AS CLOB)
  FROM RESOURCE_VIEW r WHERE equals_path(r.RES, '/test/HR/example/paper') = 1;

XMLSERIALIZE(DOCUMENTR.RESASCLOB)
--------------------------------------------------------------------------------
```

```
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd" Hidden="false" Inv
alid="false" Container="false" CustomRslv="false" VersionHistory="false" StickyR
ef="true">
  <CreationDate>2005-04-29T16:30:01.588835</CreationDate>
  <ModificationDate>2005-04-29T16:30:01.883838</ModificationDate>
  <DisplayName>My New Paper</DisplayName>
  <Language>en-US</Language>

  . . .

  <Contents>
    <binary>4F7261636C65206F7220554E4958</binary>
  </Contents>
</Resource>

1 row selected.
```

> **See Also:** Chapter 29, "User-Defined Repository Metadata" for additional examples of updating resource metadata

Note that, by default, the `DisplayName` element content, `paper`, was the same text as the last location step of the resource path, `/test/HR/example/paper`. This is only the default value, however. The `DisplayName` is independent of the resource path, so updating it does not change the path.

Element `DisplayName` is defined by the WebDAV standard, and it is recognized by WebDAV applications. Applications, such as an FTP client, that are not WebDAV-based do not recognize the `DisplayName` of a resource. An FTP client lists the resource as `paper` (using FTP command `ls`, for example) even after the `UPDATE` operation.

Example 24–19 changes the path for the resource from `/test/HR/example/paper` to `/test/myexample`. It is analogous to using the UNIX or Linux command `mv /test/HR/example/paper /test/myexample`.

Example 24–19 Updating a Path in the PATH_VIEW

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE under_path(RES, '/test') = 1;

ANY_PATH
--------
/test/HR
/test/HR/example
/test/HR/example/paper

3 rows selected.

UPDATE PATH_VIEW
  SET PATH = '/test/myexample' WHERE PATH = '/test/HR/example/paper';

ANY_PATH
--------
/test/HR
/test/HR/example
/test/myexample

3 rows selected.
```

> **See Also:** Table 21–3, " Accessing Oracle XML DB Repository: API Options" on page 21-19 for additional examples that use SQL functions that apply to `RESOURCE_VIEW` and `PATH_VIEW`

Working with Multiple Oracle XML DB Resources

The repository operations listed in Table 21–3 on page 21-19 typically apply to a single resource at a time. To perform the same operation on multiple Oracle XML DB resources, or to find one or more Oracle XML DB resources that meet a certain set of criteria, use SQL with `RESOURCE_VIEW` and `PATH_VIEW`.

For example, you can perform the following operations:

- Updating based on attributes – see Example 24–20
- Finding resources inside a folder – see Example 24–21
- Copying a set of Oracle XML DB resources – see Example 24–22

Example 24–20 Updating Resources Based on Attributes

```
UPDATE RESOURCE_VIEW
  SET RES =
    XMLQuery('copy $i := $p1 modify
                (for $j in $i/Resource/DisplayName
                 return replace value of node $j with $p2)
               return $i'
              PASSING RES AS "p1", 'My New Paper' AS "p2"
              RETURNING CONTENT)
  WHERE XMLCast(XMLQuery('declare namespace ns =
                           "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                           $r/ns:Resource/ns:DisplayName'
                          PASSING RES AS "r" RETURNING CONTENT)
                 AS VARCHAR2(128))
        = 'My Paper';

1 row updated.

SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE XMLCast(XMLQuery('declare namespace ns =
                            "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                           $r/ns:Resource/ns:DisplayName'
                          PASSING RES AS "r" RETURNING CONTENT)
                 AS VARCHAR2(128))
          = 'My New Paper';

ANY_PATH
---------------
/test/myexample

1 row selected.
```

Example 24–21 Finding Resources Inside a Folder

```
SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE under_path(resource, '/sys/schemas/PUBLIC/xmlns.oracle.com/xdb') = 1;

ANY_PATH
------------------------------------------------------------
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResource.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBSchema.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBStandard.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/acl.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/dav.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log/xdblog.xsd
```

```
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/stats.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/xdbconfig.xsd

12 rows selected.
```

The SQL DML statement in Example 24–22 copies all of the resources in folder `public` to folder `newlocation`. It is analogous to the UNIX or Linux command `cp /public/* /newlocation`. Target folder `newlocation` must exist before the copy.

Example 24–22 Copying Resources

```
SELECT PATH FROM PATH_VIEW WHERE under_path(RES, '/test') = 1;

PATH
-----------------
/test/HR
/test/HR/example
/test/myexample

3 rows selected.

INSERT INTO PATH_VIEW
  SELECT '/newlocation/' || path(1), RES, LINK, NULL FROM PATH_VIEW
    WHERE under_path(RES, '/test', 1) = 1
    ORDER BY depth(1);

3 rows created.

SELECT PATH FROM PATH_VIEW WHERE under_path(RES, '/newlocation') = 1;

PATH
------------------------
/newlocation/HR
/newlocation/HR/example
/newlocation/myexample

3 rows selected.
```

Performance Tuning of Oracle XML DB Repository Operations

This section includes some guidelines for improving the performance of repository operations such as resource creation and querying.

Folders that contain a large number of resources can negatively affect concurrency, particularly when many resources are created or deleted. As a rule of thumb, do not have folders that contain more than 10,000 resources. This empirical limit is based on the database block size and the average filename length.

If you create resources in bulk, perform a `COMMIT` operation at least every 1,000 resources. Performance can be negatively impacted if you commit very often or you commit less often than every 1,000 resource creations.

When creating a file resource that is an XML Schema-based document for which the XML schema is known, specify the XML schema URL as a parameter to PL/SQL function `DBMS_XDB_REPOS.createResource`. This saves preparsing the document to determine the XML schema.

Oracle XML DB uses configuration file `xdbconfig.xml` for configuring the system and protocol environment. This file includes an element parameter,

resource-view-cache-size, that defines the size in dynamic memory of the RESOURCE_VIEW cache. The default value is 1048576.

The performance of some queries on RESOURCE_VIEW and PATH_VIEW can be improved by tuning resource-view-cache-size. In general, the bigger the cache size, the faster the query. The default resource-view-cache-size is appropriate for most cases, but you may want to enlarge your resource-view-cache-size element when querying a sizable RESOURCE_VIEW.

The default limits for the following elements are soft limits. The system automatically adapts when these limits are exceeded.

- xdbcore-loadableunit-size – This element indicates the maximum size to which a loadable unit (partition) can grow in Kilobytes. When a partition is read into memory or a partition is built while consuming a new document, the partition is built until it reaches the maximum size. The default value is 16 KB.
- xdbcore-xobmem-bound – This element indicates the maximum memory in kilobytes that a document is allowed to occupy. The default value is 1024 KB. Once the document exceeds this number, some loadable units (partitions) are swapped out.

See Also:

- Chapter 35, "Administration of Oracle XML DB"
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL function DBMS_XDB_REPOS.createResource

Searching for Resources Using Oracle Text

Table XDB$RESOURCE in database schema XDB stores the metadata and content of repository resources. You can search for resources that contain a specific keyword by using Oracle SQL function contains with RESOURCE_VIEW or PATH_VIEW.

Example 24–23 Find All Resources Containing "Paper"

```
SELECT PATH FROM PATH_VIEW WHERE contains(RES, 'Paper') > 0;

PATH
----------------------
/newlocation/myexample
/test/myexample

2 rows selected.
```

Example 24–24 Find All Resources Containing "Paper" that are Under a Specified Path

```
SELECT ANY_PATH FROM RESOURCE_VIEW
   WHERE contains(RES, 'Paper') > 0 AND under_path(RES, '/test') > 0;

ANY_PATH
---------------
/test/myexample

1 row selected.
```

To evaluate such queries, you must first create a context index on the XDB$RESOURCE table. Depending on the type of documents stored in Oracle XML DB, choose one of the following options for creating your context index:

- *If Oracle XML DB contains only XML documents*, that is, no binary data, then a regular Context Index can be created on the XDB$RESOURCE table. This is the case for Example 24–24.

```
CREATE INDEX xdb$resource_ctx_i ON XDB.XDB$RESOURCE(OBJECT_VALUE)
  INDEXTYPE IS CTXSYS.CONTEXT;
```

  See Also: Chapter 5, "Query and Update of XML Data" and Appendix E, "Full-Text Search over XML Data Without XQuery"

- *If Oracle XML DB contains binary data* such as Microsoft Word documents, then a user filter is required to filter such documents prior to indexing. Use package DBMS_XDBT (dbmsxdbt.sql) to create and configure the Context Index.

```
-- Install the package - connected as SYS
@dbmsxdbt
-- Create the preferences
EXEC DBMS_XDBT.createPreferences;
-- Create the index
EXEC DBMS_XDBT.createIndex;
```

  See Also:

  - *Oracle Database PL/SQL Packages and Types Reference*, for information about installing and using DBMS_XDBT.
  - "PL/SQL APIs for XMLType: References" on page 11-3

Package DBMS_XDBT also includes procedures to synchronize and optimize the index. You can use procedure configureAutoSync() to automatically sync the index by using job queues.

25

Resource Versions

This chapter describes how to create and manage versions of Oracle XML DB resources.

This chapter contains these topics:

Overview of Oracle XML DB Versioning

Versioning lets you create and manage different versions of a resource in Oracle XML DB Repository. A record, or history, is kept of all changes to an Oracle XML DB resource that is under version control. When you update a version-controlled resource, Oracle XML DB stores the pre-update contents as a separate resource version – a snapshot for the historical record.

Versioning features include the following:

- Version control for a resource.

  You can turn version control on or off for an Oracle XML DB Repository resource.

- Updating a version-controlled resource.

  When Oracle XML DB updates a version-controlled resource, it creates a new version of the resource. This new version is not deleted from the database when you delete the version-controlled resource.

- Accessing a version-controlled resource.

  You can access a version-controlled resource the same way you access any other resource.

- Accessing a resource version.

  To access a particular version of a resource, you use the resource ID of that version. The resource ID can be obtained from the resource version history or from the version-controlled resource itself. See "Resource Versions and Resource IDs".

Table 25–1 lists some terms used in this chapter.

Table 25–1 Oracle XML DB Versioning Terms

Term	Description
Versionable resource	A resource that can be put under version control. All Oracle XML DB resources except folders and ACLs are versionable.
Version-controlled resource	A resource that is under version control.
Version resource	A particular version of a version-controlled resource. A version resource is itself a resource. It is system-generated, and it has no associated path name. It is read-only (it cannot be updated or deleted).
`checkOut`, `checkIn`, `unCheckOut`	Operations for managing version-controlled resources. You must use `checkOut` before you can modify a version-controlled resource. Use `checkIn` to make your changes permanent. Use `unCheckOut` to cancel your changes. (Use `COMMIT` after each of these operations.)

Note: Oracle XML DB supports version control only for Oracle XML DB resources. It does *not* support version control for user-defined tables or data in Oracle Database.

Oracle does *not* guarantee preservation of the resource ID of a version across check-in and check-out. Everything except the resource ID of the latest version is preserved.

Oracle XML DB supports versioning of XML resources that are not XML schema-based. It also supports versioning of XML schema-based resources and resources that contain XML schema-based metadata, but only if the underlying tables have *no* associated triggers or constraints.

If hierarchy is enabled for a table, then the table has a trigger. This includes tables that are created as part of XML schema registration, for which the default behavior is to enable hierarchy.

Be aware also that if you query one of the tables underlying a resource, the query can return data from multiple versions of the resource. This is because the data for the different resource versions is stored in the same underlying table, using different rows.

Overview of PL/SQL Package DBMS_XDB_VERSION

You use PL/SQL package `DBMS_XDB_VERSION` to work with resource versions. Table 25–2 summarizes the main subprograms in this package.

Table 25–2 PL/SQL Functions and Procedures in Package DBMS_XDB_VERSION

Function or Procedure	Description
`makeVersioned(pathname VARCHAR2) RETURN DBMS_ XDB_VERSION.RESID_TYPE;`	Turn a resource with the given path name into a version controlled resource. If two or more path names refer to the same resource, then the resource is copied, and argument path name is bound with the copy. The new resource is put under version control. All other path names continue to refer to the original resource. The argument is the path name of the resource to be put under version control. Returns the resource ID of the first version resource of the version-controlled resource. This is not an auto-commit SQL operation. An error is raised of you call `makeVersioned` for a folder, version resource, or ACL, or if the target resource does not exist. Note: No error or warning is raised if you call `makeVersioned` for a version-controlled resource.
`checkOut(pathname VARCHAR2);`	Check out a version-controlled resource. You cannot update or delete a version-controlled resource until you check it out. Check-out is for all users: any user can modify a resource that has been checked out. The argument is the path name of the version-controlled resource to be checked out. This is not an auto-commit SQL operation. If two users check out the same version-controlled resource at the same time, then one user must roll back. As a precaution, commit after checking out and before updating a resource. An error is raised if the target resource is not under version control, does not exist, or is already checked out.
`checkIn (pathname VARCHAR2) RETURN DBMS_ XDB_VERSION.RESID_TYPE;`	Check in a version-controlled resource that has been checked out. `pathname` - Path name of the checked-out resource. Returns the resource id of the newly created version. This is not an auto-commit SQL operation. You need not use the same path name that was used for check-out. However, the check-in path name and the check-out path name must reference the same resource, or else results are unpredictable. If the resource has been renamed, then the new name must be used when checking it in. An error is raised if the path name refers to no resource.
`unCheckOut(pathname VARCHAR2) RETURN DBMS_ XDB_VERSION.RESID_TYPE;`	Check in a checked-out resource. The argument is the path name of the checked-out resource. Returns the resource id of the version before the resource was checked out. This is not an auto-commit SQL operation. You need not use the same path name that was used for check-out. However, the `unCheckOut` path name and the check-out path name must reference the same resource, or else results are unpredictable. If the resource has been renamed, then the new name must be used for `unCheckOut`. An error is raised if the path name refers to no resource.

Table 25–2 (Cont.) PL/SQL Functions and Procedures in Package DBMS_XDB_VERSION

Function or Procedure	Description
`getPredecessors(pathname VARCHAR2) RETURN RESID_LIST_TYPE;`	Given a path name that references a version resource or a version-controlled resource, return the predecessors of the resource. Retrieving predecessors by resource ID, using function getPredsByRESID is more efficient than by path name, using function `getPredecessors`.
`getPredsByRESID(resid DBMS_XDB_VERSION.RESID_TYPE) RETURN RESID_LIST_TYPE;`	The list of predecessors returned has only one element (the parent): Oracle XML DB does not support version branching.
`getSuccessors(pathname VARCHAR2) RETURN RESID_LIST_TYPE;`	Given a version resource or a version-controlled resource, return the successors of the resource. Retrieving successors by resource ID, using function getSuccsByRESID is more efficient than by path name, using function `getSuccessors`.
`getSuccsByRESID(resid DBMS_XDB_VERSION.RESID_TYPE) RETURN RESID_LIST_TYPE;`	The list of successors returned has only one element (the parent): Oracle XML DB does not support version branching.
`getResourceByRESID(resid DBMS_XDB_VERSION.RESID_TYPE) RETURN XMLType;`	Given a resource ID, return the resource as an `XMLType` instance.

Resource Versions and Resource IDs

A resource object ID, or **resource ID**, is a unique, constant, system-generated identifier for an Oracle XML DB resource. Each resource has a resource ID. This includes *version resources*, which are system-generated resources that do not have any path names. A resource ID is sometimes called a **RESID**.

You use PL/SQL package `DBMS_XDB_VERSION` to put a resource under version-control and maBarri8ora

nage different versions of it. Some of the `DBMS_XDB_VERSION` routines accept the path name of a version-controlled resource as argument and return the resource ID of the relevant version resource.

For example, you use function `DBMS_XDB_VERSION.makeVersioned` to put a resource under version control, that is, to turn it into a version-controlled resource. It accepts as argument a repository path to the resource.

You need not use the same path name for a given version-controlled resource when you perform various versioning operations on it, but the path names you use must all refer to the same resource.

Whenever a path name is passed as an argument representing a version-controlled resource, it is the latest (that is, the current) version of the resource that is used. A *path name always stands for the latest version.* The only way you can refer to a version other than the current version is to use its resource ID.

The resource ID of a given version is constant. Remember that a version is itself a resource, and the resource ID of a resource never changes.

Each time you check in a version-controlled resource, Oracle XML DB creates a new version resource. A **version resource** is a snapshot of a resource (its content and metadata) together with a resource ID. The collection of version resources for a given version-controlled resource constitutes a historical sequence of previous versions, the **version series** or history of the resource.

When you check in a version-controlled resource that has resource ID ***R***, Oracle XML DB creates a new resource ID, ***P***, which refers to a snapshot of the resource (both content and metadata), as it was before it was last checked out. The snapshot was made before check-out, but the associated version resource (and its resource ID ***P***) are created at check-in time. Together, the new resource ID ***P*** and the snapshot it refers to thus represent the *previous*, not the current, version of the resource. Resource ID ***R*** continues to refer to the current version.

Put another way, when you check in a version-controlled resource, a version resource is created that represents the previous state of the version-controlled resource. Like any new resource, this new version resource is allocated a new resource ID (***P***).

You can think about making a version resource (check-in) the way you think about making a backup copy of a file: Just as you give a new name to the backup file, so the previous-version snapshot of a resource is given a new resource ID. The current resource retains the original resource ID, just as your working file keeps its original name.

What this means is that when you check in a resource, in order to "create a new version", what's really new is the version resource (resource ID ***P*** and the snapshot it references) that represents the *old* (previous) version. The newest, or latest, version of the resource (***R***) is really just the current version. Remember: new version resource = old (previous) version of the resource content and metadata.

Resource ID ***R*** refers to the *current* version of the version-controlled resource throughout its lifetime, from the moment it was put under version control until it is deleted. You can always access the latest version of a resource using its original resource ID.

When you need to refer to a previous version of a resource, you must use its resource ID to reference it. You cannot use a path name. You can use function `DBMS_XDB_VERSION.getPredsByRESID` to obtain the resource ID of the previous version of a given resource.

Note: If you *delete* a resource, then any subsequent reference to it, whether by resource ID or path name, raises an error (typically `ORA-31001: Invalid resource handle or path name`). You *cannot* access any version of a version-controlled resource that has been deleted.

Resource Versions and ACLs

A version resource is immutable. It is a snapshot of resource content and metadata, plus a resource ID, and both snapshot and ID are static. Likewise, the ACL of a version resource cannot be changed.

You can modify the ACL of a version-controlled resource that you have checked out. When you check it in, the modified ACL continues to be associated with the current (latest) version of the resource, and the previous version, that is, the newly created version resource, is associated with the ACL before it was modified. That is, the previous version is associated with the previous ACL, and the current version is associated with the updated ACL.

What is important to keep in mind is this:

- Different versions of a resource can have different ACLs associated with them.
- You can modify the ACL associated with the current version after you check out the resource.

- Check-in associates the ACL as it was before check-out with the newly created version resource, that is, with the previous version of the resource.
- The ACL associated with a given version remains the same.

Resource Versioning Examples

This section presents examples that do the following:

- Put a resource under version control, that is, create a version-controlled resource – Example 25–2
- Retrieve the content of the resource by referring to the resource ID – Example 25–3
- Check out the version-controlled resource (for all users) – Example 25–4
- Update the resource content – Example 25–5
- Check in the resource – Example 25–6
- Retrieve the content and metadata of both the new and old versions of the resource – Example 25–7, Example 25–8, Example 25–9
- Cancel a resource check-out – Example 25–10

Example 25–3 creates an Oracle XML DB Repository resource at repository path `/public/t1.txt`. The resource has as content the text `Mary had a little lamb`. The example uses SQL*Plus command `VARIABLE` to declare bind variables `targetPath`, `current_RESID`, and `previous_RESID`, which are used in other examples in this section.

Example 25–1 Creating a Repository Resource

```
VARIABLE targetPath      VARCHAR2(700)
VARIABLE current_RESID   VARCHAR2(32)
VARIABLE previous_RESID  VARCHAR2(32)

DECLARE
  res BOOLEAN;
BEGIN
  :targetPath  := '/public/t1.txt';
  IF (DBMS_XDB_REPOS.existsResource(:targetPath))
     THEN DBMS_XDB_REPOS.deleteResource(:targetPath);
  END IF;
  res := DBMS_XDB_REPOS.createResource(:targetPath, 'Mary had a little lamb');
END;
/
```

The new resource is *not* version-controlled. Example 25–2 uses PL/SQL function `DBMS_XDB_VERSION.makeVersioned` to put it under version control. This function returns the resource ID of the first version resource for the version-controlled resource. The function does not auto-commit. You must explicitly use `COMMIT`.

Example 25–2 Creating a Version-Controlled Resource

```
DECLARE
  resid DBMS_XDB_VERSION.RESID_TYPE;
BEGIN
  resid := DBMS_XDB_VERSION.makeVersioned(:targetPath);
  :current_RESID := resid;
  COMMIT;
END;
/
```

Example 25–2 also copies the resource ID of the new version resource to bind variable `current_RESID`. Example 25–3 shows how to use PL/SQL constructor `XDBUritype` together with PL/SQL function `createOIDPath` to retrieve the resource content by referencing the resource ID.

Example 25–3 Retrieving Resource Content by Referencing the Resource ID

```
SELECT XDBURIType(DBMS_XDB_REPOS.createOIDPath(:current_RESID)).getClob()
  FROM DUAL;

XDBURITYPE(DBMS_XDB_REPOS.CREATEOIDPATH(:CURRENT_RESID)).GETCLOB()
--------------------------------------------------------------------
Mary had a little lamb

1 row selected.
```

Example 25–4 checks out the version-controlled resource (and commits), so that it can be modified. Note that any user can modify a resource that has been checked out.

Example 25–4 Checking Out a Version-Controlled Resource

```
BEGIN
  DBMS_XDB_VERSION.checkOut(:targetPath);
  COMMIT;
END;
/
```

Example 25–5 updates the content of the checked-out resource. Before the (LOB) content can be updated, you must lock the resource. The example uses a dummy update of the resource display name (a scalar attribute) to do this.

Example 25–5 Updating Resource Content

```
DECLARE
  content        BLOB;
  newContentBlob BLOB;
  newContentClob CLOB;
  source_offset  INTEGER := 1;
  target_offset  INTEGER := 1;
  warning        INTEGER;
  lang_context   INTEGER := 0;
BEGIN
  -- Lock the resource using a dummy update.
UPDATE RESOURCE_VIEW
  SET RES =
    XMLQuery('copy $i := $p1 modify
                (for $j in $i/Resource/DisplayName
                 return replace value of node $j with $p2)
                return $i'
              PASSING
                RES AS "p1",
                XMLCast(XMLQuery('declare namespace ns =
                                    "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                                  $r/ns:Resource/ns:DisplayName/text()'
                                 PASSING RES AS "r" RETURNING CONTENT)
                        AS VARCHAR2(128)) AS "p2"
              RETURNING CONTENT)
    WHERE equals_path(res, :targetPath) = 1;
  -- Get the LOB locator.
```

```
  SELECT XMLCast(XMLQuery('declare namespace ns =
                           "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                           $r/ns:Resource/ns:XMLLob'
                          PASSING RES AS "r" RETURNING CONTENT)
                 AS BLOB)
    INTO content FROM RESOURCE_VIEW
    WHERE equals_path(RES, :targetPath) = 1;
  -- Update the LOB.
  newContentClob := 'Hickory dickory dock, the mouse ran up the clock';
  DBMS_LOB.createTemporary(newContentBlob, false, DBMS_LOB.CALL);
  DBMS_LOB.convertToBlob(newContentBlob, newContentClob,
                         DBMS_LOB.getLength(newContentClob),
                         source_offset, target_offset,
                         nls_charset_id('AL32UTF8'), lang_context, warning);
  DBMS_LOB.open(content, DBMS_LOB.lob_readwrite);
  DBMS_LOB.trim(content, 0);
  DBMS_LOB.append(content, newContentBlob);
  DBMS_LOB.close(content);
  DBMS_LOB.freeTemporary(newContentBlob);
  DBMS_LOB.freeTemporary(newContentClob);
  COMMIT;
END;
/
```

Example 25–5 retrieves the LOB content using the LOB locator, which is element `/ns:Resource/ns:XMLLob`. It empties the existing content and adds new content using PL/SQL procedures `trim` and `append` in package `DBMS_LOB`. It commits the content change.

> **See Also:** *Oracle Database SecureFiles and Large Objects Developer's Guide* for information about updating a LOB

At this point, the content has been modified, but this change has not been recorded in the version series. Example 25–6 checks in the resource and commits the check-in.

Example 25–6 Checking In a Version-Controlled Resource

```
DECLARE
  resid DBMS_XDB_VERSION.RESID_TYPE;
BEGIN
  resid := DBMS_XDB_VERSION.checkIn(:targetPath);
  :previous_RESID := DBMS_XDB_VERSION.getPredsByRESID(resid)(1);
  COMMIT;
END;
/
```

PL/SQL function `checkIn` returns the resource ID of the current version, which is the same as `current_RESID`. Example 25–6 passes this value to PL/SQL function `getPredsByRESID`. This function returns the list of resource IDs for the (immediate) predecessors of its argument resource.[1] Example 25–6 assigns the first (and only) element of this list to bind variable `previous_RESID`.

At this point, the value of `current_RESID` is the resource ID of the current version, and the value of `previous_RESID` is the resource ID of the previous version.

[1] In Oracle XML DB, a version resource always has a *single* predecessor, that is, a single version that immediately precedes it. The WebDAV standard provides for the possibility of multiple predecessors.

You can retrieve the content or metadata of a resource using any of the following methods:

- PL/SQL constructor `XDBURIType`, together with PL/SQL function `DBMS_XDB_REPOS.createOIDPath` – Retrieve content. See Example 25–3 and Example 25–7.
- PL/SQL function `DBMS_XDB_VERSION.getContentsCLOBByRESID` – Retrieve content. See Example 25–8.
- PL/SQL function `DBMS_XDB_VERSION.getResourceByRESID` – Retrieve metadata. See Example 25–9.

You can use constructor `XDBURIType` with function `createOIDPath` to access resource content using protocols. For example, you could have Oracle XML DB serve up various versions of a graphic image file resource for a Web page, setting the `HREF` for the HTML `IMAGE` tag to a value returned by `createOIDPath`.

Example 25–7 through Example 25–9 use these different methods to retrieve the two versions of the resource addressed by bind variables `current_RESID` and `previous_RESID` after check-in.

Example 25–7 Retrieving Resource Version Content Using XDBURITYPE and CREATEOIDPATH

```
SELECT XDBURIType(DBMS_XDB_REPOS.createOIDPath(:current_RESID)).getClob()
  FROM DUAL;

XDBURITYPE(DBMS_XDB_REPOS.CREATEOIDPATH(:CURRENT_RESID)).GETCLOB()
--------------------------------------------------------------------
Mary had a little lamb

1 row selected.

SELECT XDBURIType(DBMS_XDB_REPOS.createOIDPath(:previous_RESID)).getClob()
  FROM DUAL;

XDBURITYPE(DBMS_XDB_REPOS.CREATEOIDPATH(:PREVIOUS_RESID)).GETCLOB()
--------------------------------------------------------------------
Hickory dickory dock, the mouse ran up the clock

1 row selected.
```

Example 25–8 Retrieving Resource Version Content Using GETCONTENTSCLOBBYRESID

```
SELECT DBMS_XDB_VERSION.getContentsCLOBByRESID(:current_RESID) FROM DUAL;

DBMS_XDB_VERSION.GETCONTENTSCLOBBYRESID(:CURRENT_RESID)
------------------------------------------------------
Mary had a little lamb

1 row selected.

SELECT DBMS_XDB_VERSION.getContentsCLOBByRESID(:previous_RESID) FROM DUAL;

DBMS_XDB_VERSION.GETCONTENTSCLOBBYRESID(:PREVIOUS_RESID)
------------------------------------------------------
Hickory dickory dock, the mouse ran up the clock

1 row selected.
```

Example 25–9 Retrieving Resource Version Metadata Using GETRESOURCEBYRESID

```
SELECT XMLSerialize(DOCUMENT DBMS_XDB_VERSION.getResourceByRESID(:current_RESID)
                    AS CLOB INDENT SIZE = 2)
  FROM DUAL;
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd" Hidden="false"
          Invalid="false" VersionID="2" ActivityID="0" Container="false"
          CustomRslv="false" VersionHistory="false" StickyRef="true">
  <CreationDate>2009-05-06T12:33:34.012133</CreationDate>
  <ModificationDate>2009-05-06T12:33:34.280199</ModificationDate>
  <DisplayName>t1.txt</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>text/plain</ContentType>
  <RefCount>1</RefCount>
  <ACL>
    <acl description="Public:All privileges to PUBLIC"
         xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                             http://xmlns.oracle.com/xdb/acl.xsd"
         shared="true">
      <ace>
        <grant>true</grant>
        <principal>PUBLIC</principal>
        <privilege>
          <all/>
        </privilege>
      </ace>
    </acl>
  </ACL>
  <Owner>HR</Owner>
  <Creator>HR</Creator>
  <LastModifier>HR</LastModifier>
  <SchemaElement>http://xmlns.oracle.com/xdb/XDBSchema.xsd#text</SchemaElement>
  <Contents>
    <text>Mary had a little lamb</text>
  </Contents>
  <VCRUID>69454F2EF12E3375E040578C8A1764B5</VCRUID>
  <Parents>69454F2EF12F3375E040578C8A1764B5</Parents>
</Resource>

1 row selected.

SELECT XMLSerialize(DOCUMENT DBMS_XDB_VERSION.getResourceByRESID(:previous_RESID)
                    AS CLOB INDENT SIZE = 2)
  FROM DUAL;
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd" Hidden="false"
          Invalid="false" VersionID="1" Container="false" CustomRslv="false"
          VersionHistory="false" StickyRef="true">
  <CreationDate>2009-05-06T12:33:34.012133</CreationDate>
  <ModificationDate>2009-05-06T12:33:34.012133</ModificationDate>
  <DisplayName>t1.txt</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>text/plain</ContentType>
  <RefCount>0</RefCount>
  <ACL>
    <acl description="Public:All privileges to PUBLIC"
         xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
```

```
        xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                            http://xmlns.oracle.com/xdb/acl.xsd"
        shared="true">
      <ace>
        <grant>true</grant>
        <principal>PUBLIC</principal>
        <privilege>
          <all/>
        </privilege>
      </ace>
    </acl>
  </ACL>
  <Owner>HR</Owner>
  <Creator>HR</Creator>
  <LastModifier>HR</LastModifier>
  <SchemaElement>http://xmlns.oracle.com/xdb/XDBSchema.xsd#text</SchemaElement>
  <Contents>
    <text>Hickory dickory dock, the mouse ran up the clock</text>
  </Contents>
  <VCRUID>69454F2EF12E3375E040578C8A1764B5</VCRUID>
</Resource>

1 row selected.
```

You can cancel a check-out using PL/SQL function `DBMS_XDB_VERSION.unCheckOut`. Example 25–10 illustrates this.

Example 25–10 Canceling a Check-Out Using UNCHECKOUT

```
DECLARE
  resid DBMS_XDB_VERSION.RESID_TYPE;
BEGIN
  resid := DBMS_XDB_VERSION.unCheckOut(:targetPath);
END;
/
```

26

PL/SQL Access to Oracle XML DB Repository

This chapter describes the Oracle XML DB resource application program interface (API) for PL/SQL. There are two PL/SQL packages for this:

- `DBMS_XDB_CONFIG` – Configure Oracle XML DB and its repository
- `DBMS_XDB_REPOS` – Other, non-configuration operations on the repository

The chapter contains these topics:

See Also:

- "PL/SQL APIs for XMLType: References" on page 11-3
- "Package DBMS_XDB_ADMIN" on page 35-13

DBMS_XDB_REPOS: Access and Manage Repository Resources

PL/SQL package `DBMS_XDB_REPOS` is used by application developers to access and manage resources in Oracle XML DB Repository. It includes methods for managing resource security based on access control lists (ACLs). An ACL is a list of access control entries (ACEs) that determines which principals (users and roles) have access to which resources.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Table 26–1 describes the functions and procedures in package `DBMS_XDB_REPOS`.

Table 26–1 DBMS_XDB_REPOS Resource Access and Management Subprograms

Function/Procedure	Description
`addResource`	Insert a new file resource into the repository hierarchy, with the given string as its contents.
`appendResourceMetadata`	Add user-defined metadata to a resource.
`createFolder`	Create a new folder resource.
`createOIDPath`	Create a virtual path to a resource, based on its object identifier (OID).
`createResource`	Create a new file resource.
`deleteResource`	Delete a resource from the repository.

Table 26–1 (Cont.) DBMS_XDB_REPOS Resource Access and Management Subprograms

Function/Procedure	Description
deleteResourceMetadata	Delete specific user-defined metadata from a resource.
existsResource	Indicate whether or not a resource exists, given its absolute path.
getContentBLOB	Return the contents of a resource as a BLOB instance.
getContentVARCHAR2	Return the contents of a resource as a VARCHAR2 value.
getContentXMLRef	Return the contents of a resource as a reference to an XMLType instance.
getContentXMLType	Return the contents of a resource as an XMLType instance.
getLockToken	Return a resource lock token for the current user, given a path to the resource.
getResOID	Return the object identifier (OID) of a resource, given its absolute path.
getResource	Return the instance of class DBMS_XDBRESOURCE.XDBResource that is located at a given path in the repository.
getXDB_tablespace	Return the current tablespace of database schema (user account) XDB.
hasBLOBContent	Return TRUE if a given resource has BLOB content.
hasCharContent	Return TRUE if a given resource has character content.
hasXMLContent	Return TRUE if a given resource has XMLType content.
hasXMLReference	Return TRUE if a given resource has a reference to XMLType content.
isFolder	Return TRUE if a given resource is a folder.
link	Create a link to an existing resource.
lockResource	Obtain a WebDAV-style lock on a resource, given a path to the resource.
processLinks	Process all XLink and XInclude links in a document or folder.
purgeResourceMetadata	Delete all user-defined metadata from a given resource.
refreshContentSize	Recompute the content size of a given resource.
renameResource	Rename a given resource.
touchResource	Change the last-modified time to the current time.
unlockResource	Unlock a resource, given its lock token and path.
updateResourceMetadata	Modify user-defined resource metadata.

Example 26–1 uses package DBMS_XDB_REPOS to manage repository resources. It creates the following:

- A folder, mydocs, under folder /public
- Two file resources, emp_selby.xml and emp_david.xml
- Two links to the file resources person_selby.xml and person_david.xml

It then deletes each of the newly created resources and links. The folder contents are deleted before the folder itself.

Example 26–1 Managing Resources Using DBMS_XDB_REPOS

```
DECLARE
  retb BOOLEAN;
BEGIN
  retb := DBMS_XDB_REPOS.createfolder('/public/mydocs');
  retb := DBMS_XDB_REPOS.createresource('/public/mydocs/emp_selby.xml',
```

```
                                          '<emp_name>selby</emp_name>');
  retb := DBMS_XDB_REPOS.createresource('/public/mydocs/emp_david.xml',
                                          '<emp_name>david</emp_name>');
END;
/
PL/SQL procedure successfully completed.

CALL DBMS_XDB_REPOS.link('/public/mydocs/emp_selby.xml',
                         '/public/mydocs',
                         'person_selby.xml');
Call completed.

CALL DBMS_XDB_REPOS.link('/public/mydocs/emp_david.xml',
                         '/public/mydocs',
                         'person_david.xml');
Call completed.

CALL DBMS_XDB_REPOS.deleteresource('/public/mydocs/emp_selby.xml');
Call completed.

CALL DBMS_XDB_REPOS.deleteresource('/public/mydocs/person_selby.xml');
Call completed.

CALL DBMS_XDB_REPOS.deleteresource('/public/mydocs/emp_david.xml');
Call completed.

CALL DBMS_XDB_REPOS.deleteresource('/public/mydocs/person_david.xml');
Call completed.

CALL DBMS_XDB_REPOS.deleteresource('/public/mydocs');
Call completed.
```

> **See Also:** Chapter 29, "User-Defined Repository Metadata" for examples using `appendResourceMetadata` and `deleteResourceMetadata`

DBMS_XDB_REPOS: ACL-Based Security Management

Table 26–2 lists the `DBMS_XDB_REPOS` Oracle XML DB ACL- based security management functions and procedures.

Table 26–2 DBMS_XDB_REPOS: Security Management Subprograms

Function/Procedure	Description
`ACLCheckPrivileges`	Check the access privileges granted to the current user by an ACL.
`changeOwner`	Change the owner of a given resource to a given user.
`changePrivileges`	Add an ACE to a resource ACL.
`checkPrivileges`	Check the access privileges granted to the current user for a resource.
`getACLDocument`	Return the ACL document that protects a resource, given the path name of the resource.
`getPrivileges`	Return all privileges granted to the current user for a resource.
`setACL`	Set the ACL for a resource.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference*
- *Oracle XML Developer's Kit Programmer's Guide*

The examples in this section illustrate the use of these functions and procedures.

In Example 26–2, database user HR creates two resources: a folder, /public/mydocs, with a file in it, emp_selby.xml. Procedure getACLDocument is called on the file resource, showing that the <principal> user for the document is PUBLIC.

Example 26–2 Using DBMS_XDB_REPOS.GETACLDOCUMENT

```
CONNECT hr
Enter password: password

Connected.

DECLARE
  retb BOOLEAN;
BEGIN
  retb := DBMS_XDB_REPOS.createFolder('/public/mydocs');
  retb := DBMS_XDB_REPOS.createResource('/public/mydocs/emp_selby.xml',
                                        '<emp_name>selby</emp_name>');
END;
/
PL/SQL procedure successfully completed.

SELECT XMLSerialize(DOCUMENT
                    DBMS_XDB_REPOS.getACLDocument('/public/mydocs/emp_selby.xml')
                    AS CLOB)
  FROM DUAL;

XMLSERIALIZE(DOCUMENTDBMS_XDB_REPOS.GETACLDOCUMENT('/PUBLIC/MYDOCS/EMP_SELBY.XML
--------------------------------------------------------------------------------
<acl description="Public:All privileges to PUBLIC" xmlns="http://xmlns.oracle.co
m/xdb/acl.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaL
ocation="http://xmlns.oracle.com/xdb/acl.xsd                          http://xm
lns.oracle.com/xdb/acl.xsd" shared="true">
  <ace>
    <grant>true</grant>
    <principal>PUBLIC</principal>
    <privilege>
      <all/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

In Example 26–3, the system manager connects and uses procedure setACL to give the owner (database schema HR) all privileges on the file resource created in Example 26–2. Procedure getACLDocument then shows that the <principal> user is dav:owner, the owner (HR).

Example 26–3 Using DBMS_XDB_REPOS.SETACL

```
CONNECT SYSTEM
Enter password: password

Connected.
```

```
-- Give all privileges to owner, HR.
CALL DBMS_XDB_REPOS.setACL('/public/mydocs/emp_selby.xml',
                           '/sys/acls/all_owner_acl.xml');
Call completed.
COMMIT;
Commit complete.

SELECT XMLSerialize(DOCUMENT
                    DBMS_XDB_REPOS.getACLDocument('/public/mydocs/emp_selby.xml')
                    AS CLOB)
  FROM DUAL;

XMLSERIALIZE(DOCUMENTDBMS_XDB_REPOS.GETACLDOCUMENT('/PUBLIC/MYDOCS/EMP_SELBY.XML
--------------------------------------------------------------------------------
<acl description="Private:All privileges to OWNER only and not accessible to oth
ers" xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:" xmlns:xsi="htt
p://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.
com/xdb/acl.xsd http://xmlns.oracle.com/xdb/acl.xsd" shared="true">
  <ace>
    <grant>true</grant>
    <principal>dav:owner</principal>
    <privilege>
      <all/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

In Example 26–4, user HR connects and uses function changePrivileges to add a new access control entry (ACE) to the ACL, which gives all privileges on resource emp_selby.xml to user oe. Procedure getACLDocument shows that the new ACE was added to the ACL.

Example 26–4 Using DBMS_XDB_REPOS.CHANGEPRIVILEGES

```
CONNECT hr
Enter password: password

Connected.

SET SERVEROUTPUT ON

-- Add an ACE giving privileges to user OE
DECLARE
  r        PLS_INTEGER;
  ace      XMLType;
  ace_data VARCHAR2(2000);
BEGIN
  ace_data := '<ace xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                    xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                        http://xmlns.oracle.com/xdb/acl.xsd
                                        DAV:http://xmlns.oracle.com/xdb/dav.xsd">
                <principal>OE</principal>
                <grant>true</grant>
                <privilege><all/></privilege>
              </ace>';
  ace := XMLType.createXML(ace_data);
```

```
  r := DBMS_XDB_REPOS.changePrivileges('/public/mydocs/emp_selby.xml', ace);
END;
/

PL/SQL procedure successfully completed.

COMMIT;

SELECT XMLSerialize(DOCUMENT
                    DBMS_XDB_REPOS.getACLDocument('/public/mydocs/emp_selby.xml')
                    AS CLOB)
  FROM DUAL;

XMLSERIALIZE(DOCUMENTDBMS_XDB_REPOS.GETACLDOCUMENT('/PUBLIC/MYDOCS/EMP_SELBY.XML
--------------------------------------------------------------------------------
<acl description="Private:All privileges to OWNER only and not accessible to oth
ers" xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:" xmlns:xsi="htt
p://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.
com/xdb/acl.xsd                          http://xmlns.oracle.com/xdb/acl.xsd" s
hared="false">
  <ace>
    <grant>true</grant>
    <principal>dav:owner</principal>
    <privilege>
      <all/>
    </privilege>
  </ace>
  <ace>
    <grant>true</grant>
    <principal>OE</principal>
    <privilege>
      <all/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

In Example 26–5, user `oe` connects and calls `DBMS_XDB_REPOS.getPrivileges`, which shows all of the privileges granted to user `oe` on resource `emp_selby.xml`.

Example 26–5 Using DBMS_XDB_REPOS.GETPRIVILEGES

```
CONNECT oe
Enter password: password

Connected.

SELECT XMLSerialize(DOCUMENT
                    DBMS_XDB_REPOS.getPrivileges('/public/mydocs/emp_selby.xml')
                    AS CLOB)
  FROM DUAL;

XMLSERIALIZE(DOCUMENTDBMS_XDB_REPOS.GETPRIVILEGES('/PUBLIC/MYDOCS/EMP_SELBY.XML'
--------------------------------------------------------------------------------
<privilege xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:xsi="http://www.w3.
org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl
.xsd http://xmlns.oracle.com/xdb/acl.xsd DAV: http://xmlns.oracle.com/xdb/dav.xs
d" xmlns:xdbacl="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:">
  <read-properties/>
```

```
  <read-contents/>
  <write-config/>
  <link/>
  <unlink/>
  <read-acl/>
  <write-acl-ref/>
  <update-acl/>
  <resolve/>
  <link-to/>
  <unlink-from/>
  <dav:lock/>
  <dav:unlock/>
  <dav:write-properties/>
  <dav:write-content/>
  <dav:execute/>
  <dav:take-ownership/>
  <dav:read-current-user-privilege-set/>
</privilege>

1 row selected.
```

DBMS_XDB_CONFIG: Configuration Management

Table 26–3 lists the DBMS_XDB_CONFIG Oracle XML DB configuration management functions and procedures.

Table 26–3 DBMS_XDB_CONFIG: Configuration Management Subprograms

Function/Procedure	Description
addHTTPExpireMapping	Add a mapping of a URL pattern to an expiration date to table XDB$CONFIG. The mapping controls the Expire headers for URLs that match the pattern.
addMIMEMapping	Add a MIME mapping to table XDB$CONFIG.
addSchemaLocMapping	Add a schema-location mapping to table XDB$CONFIG.
addServlet	Add a servlet to table XDB$CONFIG.
addServletMapping	Add a servlet mapping to table XDB$CONFIG.
addServletSecRole	Add a security role reference to a servlet.
addXMLExtension	Add an XML extension to table XDB$CONFIG.
cfg_get	Return the configuration information for the current session.
cfg_refresh	Refresh the session configuration information using the current Oracle XML DB configuration file, xdbconfig.xml.
cfg_update	Update the Oracle XML DB configuration information. This writes the configuration file, xdbconfig.xml.
deleteHTTPExpireMapping	Delete *all* mappings of a given URL pattern to an expiration date from table XDB$CONFIG.
deleteMIMEMapping	Delete a MIME mapping from table XDB$CONFIG.
deleteSchemaLocMapping	Delete a schema-location mapping from table XDB$CONFIG.
deleteServlet	Delete a servlet from table XDB$CONFIG.
deleteServletMapping	Delete a servlet mapping from table XDB$CONFIG.
deleteServletSecRole	Delete a security role reference from a servlet.
deleteXMLExtension	Delete an XML extension from table XDB$CONFIG.

Table 26–3 (Cont.) DBMS_XDB_CONFIG: Configuration Management Subprograms

Function/Procedure	Description
enableDigestAuthentication	Enable digest authentication.
getFTPPort	Return the current FTP port number.
getHTTPConfigRealm	Return the HTTP configuration realm.
getHTTPPort	Return the current HTTP port number.
getListenerEndPoint	Return the parameters of a listener end point for the HTTP server.
setFTPPort	Set the Oracle XML DB FTP port to the specified port number.
setHTTPConfigRealm	Set the HTTP configuration realm.
setHTTPPort	Set the Oracle XML DB HTTP port to the specified port number.
setListenerEndPoint	Set the parameters of a listener end point for the HTTP server.
setListenerLocalAccess	Either (a) restrict all listener end points to listen on only the localhost interface or (b) allow all listener end points to listen on both localhost and non-localhost interfaces.
usedPort	Return the ports used by other pluggable databases (PDBs) in the same multitenant container database (CDB). The return value is an XMLType instance that lists each PDB by id number and its associated ports by type and number.

See Also: *Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDB_CONFIG"

The examples in this section illustrate the use of these functions and procedures.

Example 26–6 uses function cfg_get to retrieve the Oracle XML DB configuration file, xdbconfig.xml.

Example 26–6 Using DBMS_XDB_CONFIG.CFG_GET

```
CONNECT SYSTEM
Enter password: password

Connected.

SELECT DBMS_XDB_CONFIG.cfg_get() FROM DUAL;

DBMS_XDB_CONFIG.CFG_GET()
--------------------------------------------------------------------------------
<xdbconfig xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd" xmlns:xsi="http://w
ww.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.com/x
db/xdbconfig.xsd                                    http://xmlns.oracle.com/xdb
/xdbconfig.xsd">
  <sysconfig>
    <acl-max-age>19</acl-max-age>
    <acl-cache-size>32</acl-cache-size>
    <invalid-pathname-chars/>
    <case-sensitive>true</case-sensitive>
    <call-timeout>6000</call-timeout>
    <max-link-queue>65536</max-link-queue>
    <max-session-use>100</max-session-use>
    <persistent-sessions>false</persistent-sessions>
    <default-lock-timeout>3600</default-lock-timeout>
    <xdbcore-logfile-path>/sys/log/xdblog.xml</xdbcore-logfile-path>
```

```
    <xdbcore-log-level>0</xdbcore-log-level>
    <resource-view-cache-size>1048576</resource-view-cache-size>
    <protocolconfig>
      <common>
        . . .
      </common>
      <ftpconfig>
        . . .
      </ftpconfig>
      <httpconfig>
        <http-port>0</http-port>
        <http-listener>local_listener</http-listener>
        <http-protocol>tcp</http-protocol>
        <max-http-headers>64</max-http-headers>
        <max-header-size>16384</max-header-size>
        <max-request-body>2000000000</max-request-body>
        <session-timeout>6000</session-timeout>
        <server-name>XDB HTTP Server</server-name>
        <logfile-path>/sys/log/httplog.xml</logfile-path>
        <log-level>0</log-level>
        <servlet-realm>Basic realm=&quot;XDB&quot;</servlet-realm>
        <webappconfig>
        . . .
        </webappconfig>
        <authentication>
        . . .
        </authentication>
    </protocolconfig>
    <xdbcore-xobmem-bound>1024</xdbcore-xobmem-bound>
    <xdbcore-loadableunit-size>16</xdbcore-loadableunit-size>
    <acl-evaluation-method>ace-order</acl-evaluation-method>
  </sysconfig>
</xdbconfig>

1 row selected.
```

Example 26–7 illustrates the use of procedure `cfg_update`. The current configuration is retrieved as an `XMLType` instance and modified. It is then rewritten using `cfg_update`.

Example 26–7 Using DBMS_XDB_CONFIG.CFG_UPDATE

```
DECLARE
  configxml    SYS.XMLType;
  configxml2   SYS.XMLType;
BEGIN
  -- Get the current configuration
  configxml := DBMS_XDB_CONFIG.cfg_get();

  -- Modify the configuration
SELECT XMLQuery(
  'declare default element namespace
   "http://xmlns.oracle.com/xdb/xdbconfig.xsd"; (: :)
   copy $i := $p1 modify
     (for $j in $i/xdbconfig/sysconfig/protocolconfig/httpconfig/http-port
      return replace value of node $j with $p2)
     return $i'
    PASSING CONFIGXML AS "p1", '8000' AS "p2" RETURNING CONTENT)
  INTO configxml2 FROM DUAL;

  -- Update the configuration to use the modified version
```

```
  DBMS_XDB_CONFIG.cfg_update(configxml2);
END;
/

PL/SQL procedure successfully completed.

SELECT DBMS_XDB_CONFIG.cfg_get() FROM DUAL;

DBMS_XDB_CONFIG.CFG_GET()
--------------------------------------------------------------------------------
<xdbconfig xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd" xmlns:xsi="http://w
ww.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.com/x
db/xdbconfig.xsd http://xmlns.oracle.com/xdb/xdbconfig.xsd">
  <sysconfig>
    <acl-max-age>15</acl-max-age>
    <acl-cache-size>32</acl-cache-size>
    <invalid-pathname-chars/>
    <case-sensitive>true</case-sensitive>
    <call-timeout>6000</call-timeout>
    <max-link-queue>65536</max-link-queue>
    <max-session-use>100</max-session-use>
    <persistent-sessions>false</persistent-sessions>
    <default-lock-timeout>3600</default-lock-timeout>
    <xdbcore-logfile-path>/sys/log/xdblog.xml</xdbcore-logfile-path>
    <resource-view-cache-size>1048576</resource-view-cache-size>
    <protocolconfig>
      <common>
      . . .
      </common>
      <ftpconfig>
      . . .
      </ftpconfig>
      <httpconfig>
        <http-port>8000</http-port>
        . . .
      </httpconfig>
    </protocolconfig>
    <xdbcore-xobmem-bound>1024</xdbcore-xobmem-bound>
    <xdbcore-loadableunit-size>16</xdbcore-loadableunit-size>
    <acl-evaluation-method>ace-order</acl-evaluation-method>
</xdbconfig>

1 row selected.
```

27

Repository Access Control

Oracle Database provides classic database security such as row-level and column-level secure access by database users. It also provides fine-grained access control for resources in Oracle XML DB Repository. This chapter describes the latter. It includes how to create, set, and modify access control lists (ACLs) and how ACL security interacts with other Oracle Database security mechanisms.

This chapter contains these topics:

See Also:

- Chapter 28, "Repository Access Using Protocols" for more information about WebDAV
- Chapter 35, "Administration of Oracle XML DB" for information about configuring and administering resource security
- "PL/SQL APIs for XMLType: References" on page 11-3 for information about the PL/SQL APIs you can use to manage resource security

Access Control Concepts

This section describes several access control terms and concepts. Each of the entities described here, user, role, principal, privilege, access control list (ACL), and access control entry (ACE), is implemented declaratively as an XML document or fragment.

Secure authorization requires defining which users, applications, or functions can have access to which data, to perform which kinds of operations. There are thus three dimensions: (1) *which users* can (2) perform *which operations* (3) on *which data*. We speak

of (1) principals, (2) privileges, and (3) objects, corresponding to these three dimensions, respectively. Principals are users or roles.

Principals and privileges (dimensions 1 and 2) are related in a declarative way by defining *access control lists*. These are then related to the third dimension, data, in various ways, either declaratively or procedurally. For example, you can protect an Oracle XML DB Repository resource or table data by using PL/SQL procedure `DBMS_XDB_REPOS.setACL` to set its controlling ACL.

Authentication and Authorization

The term **authentication** refers to verifying the *identity* of something (for example, a user, device, or application). The term **authorization** refers to verifying whether something that has been authenticated is allowed to *access* something else (for example, a database table or WebDAV resource).

This chapter concerns the authorization of principals of various kinds to access Oracle XML DB Repository resources. It also covers authentication of application-specific principals.

Principal: A User or Role

In the context of fine-grained database access control, a **principal** is a user or a role. A **user** can be any person or application that accesses information in the database. A **role** is composed of users and possibly other roles, but this recursion cannot be circular. Ultimately, each role, and thus each principal, corresponds to a *set of users*.

A user is represented for access control purposes by an XML fragment with element `user`. A role is represented by a fragment with element `role`.

Oracle Database supports the following as principals:

- Database users and **database roles**. A **database user** is also sometimes referred to as a database **schema** or a user **account**. When a person or application logs onto the database, it uses a database user (schema) and password. A **database role** corresponds to a set of database privileges that can be granted to database users, applications, or other database roles—see "Database Roles Map Database Privileges to Users" on page 27-2.
- LDAP users and groups of LDAP users. For details about using **LDAP principals** see "Integration Of Oracle XML DB with LDAP" on page 27-18.

When a term such as "user" or "role" is used here without qualification, it applies to all types of user or role. When it is important to distinguish the type, the qualifier "database" or "LDAP" is used.

Database Roles Map Database Privileges to Users

A database role is *granted* privileges, just as a database user can be granted privileges. A database role serves as an intermediary for mapping database privileges to database users (and applications): a role is granted privileges, and the role is then granted to users (giving them the privileges).

The line between a group of users and a group of privileges that are granted to those users is blurred a bit in the concept of database role: the role can serve to group the privileges that are mapped to the users and to group the users to which the privileges are mapped. The mapping is done by defining the role and granting it to users, and traditional database terminology considers the role to be the same thing as the set of privileges that are granted to it.

In the context of fine-grained access control, a different mechanism, an *access control list* (ACL), is used as the intermediary that maps privileges to users. A role is simply a set of users. In this context, the act of associating privileges with users and with roles is not a database grant. It is a declarative ACL entry, together with a run-time evaluation of ACLs and resolution of ACL conflicts.

Please keep this terminology difference in mind, to avoid confusion. As a means of mapping privileges to users, a database role combines some of the functionality that in an access-control context is divided into (1) principals, (2) privileges, and (3) ACLs. In access control terminology, roles are classified with users as principals. In traditional database terminology, roles are instead classified as sets of privileges.

Principal DAV::owner

You can use principal `DAV::owner` in connection with a given Oracle XML DB Repository resource to refer to the resource owner. The owner of a resource is one of the properties of the resource. You can use principal `DAV::owner` to facilitate ACL sharing among principals, because the owner of a resource often has special rights.

Privilege: A Permission

A **privilege** is a particular right or permission that can be granted or denied to a principal. A privilege is aggregate or atomic:

- **Aggregate** privilege – A privilege that includes other privileges.
- **Atomic** privilege – A privilege that does not include other privileges. It cannot be subdivided.

Aggregate privileges simplify usability when the number of privileges becomes large, and they promote interoperability between ACL clients. See "Privileges" on page 27-5.

Aggregate privileges retain their identity: they are not decomposed into the corresponding atomic (leaf) privileges. In WebDAV terms, Oracle Database aggregate privileges are not abstract. This implies that an aggregate privilege acts as a set of pointers to its component privileges, rather than a copy of those components. Thus, an aggregate privilege is always up to date, even if the definition of a component changes.

The set of privileges granted to a principal controls whether that principal can perform a given operation on the data that it protects. For example, if the principal (database user) `HR` wants to perform the `read` operation on a given resource, then read privileges must be granted to principal `HR` prior to the read operation.

Access Control Entry (ACE)

An **access control entry** (**ACE**) is an XML element (`ace`) that is an entry in an access control list (ACL). An ACE either grants or denies access to some repository resource or other database data by a particular principal (user or role). The ACE does not, itself, specify which data to protect. That is done outside the ACE and the ACL, by associating the ACL with target data. One way to make that association is by using PL/SQL procedure `DBMS_XDB_REPOS.setACL`.

See "ACL and ACE Evaluation" on page 27-8.

An Oracle XML DB ACE either grants or denies privileges for a principal. An **`ace`** element has the following:

- Operation `grant`: either `true` (to grant) or `false` (to deny) access.

- Either a valid principal (element `principal`) or a completed list of principals (element `invert`).
- Privileges: A set of privileges to be granted or denied for a particular principal (element `privilege`).
- Principal format (optional): The format of the principal. An LDAP distinguished name (DN), a short name (database user/role or LDAP nickname), or an LDAP globally unique identifier (GUID). The default value is `short name`. If the principal name matches both a database user and an LDAP nickname, it is assumed to refer to the LDAP nickname.
- Collection (optional): A `BOOLEAN` attribute that specifies whether the principal is a collection of users (LDAP group or database role) or a single user (LDAP user or database user).

Example 27–1 shows a simple ACE that grants privilege `DAV::all` to principal `DAV::owner`. It thus grants all privileges to the owner of the resource to which its ACL applies.

Example 27–1 Simple Access Control Entry (ACE) that Grants a Privilege

```
<ace>
  <grant>true</grant>
  <principal>DAV::owner</principal>
  <privilege>
    <DAV::all/>
  </privilege>
</ace>
```

Access Control List (ACL)

An **access control list** (**ACL**) is a list of access control entries (ACEs). By default, order in the list is relevant (see "ACL and ACE Evaluation" on page 27-8). Example 27–2 shows a simple ACL that contains only the ACE of Example 27–1.

Example 27–2 Simple Access Control List (ACL) that Grants a Privilege

```
<acl description="myacl"
     xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
     xmlns:dav="DAV:"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                         http://xmlns.oracle.com/xdb/acl.xsd">
  <ace>
    <grant>true</grant>
    <principal>dav:owner</principal>
    <privilege>
      <dav:all/>
    </privilege>
  </ace>
</acl>
```

Database Privileges for Repository Operations

Table 27–1 shows the database privileges required for some common operations on resources in Oracle XML DB Repository. In addition to the privileges listed in column **Privileges Required** you must have the `resolve` privilege for the folder containing the resource and for all of its parent folders, up to the root folder.

Table 27–1 Database Privileges Needed for Operations on Oracle XML DB Resources

Operation	Description	Privileges Required
CREATE	Create a new resource in folder F	update and link on folder F
DELETE	Delete resource R from folder F	update and unlink-from on R, update and unlink on folder F
UPDATE	Update the contents or properties of resources R	update on R
GET	An FTP or HTTP(S) retrieval of resource R	read-properties, read-contents on R
SET_ACL	Set the ACL of a resource R	DAV::write-acl on R
LIST	List the resources in folder F	read-properties on folder F, read-properties on resources in folder F. Only those resources on which the user has read-properties privilege are listed.

See Also: "Upgrade or Downgrade of an Existing Oracle XML DB Installation" on page 35-1 for information about treatment of database access privileges when upgrading

Privileges

This section describes the privileges that are provided with Oracle Database. These include the standard WebDAV privileges, which use the WebDAV namespace **DAV:**[1], and Oracle-specific privileges, which use the Oracle XML DB ACL namespace, http://xmlns.oracle.com/xdb/acl.xsd, which has the predefined prefix **xdb**.

See Also: RFC 3744: "Web Distributed Authoring and Versioning (WebDAV) Access Control Protocol", IETF Network Working Group Request For Comments #3744, May 2004

Atomic Privileges

Table 27–2 lists the atomic privileges.

Table 27–2 Atomic Privileges

Atomic Privilege	Description	Database Counterpart
DAV::lock	Lock a resource using WebDAV locks.	UPDATE
DAV::read-current-user-privilege-set	Access the DAV::current-user-privilege-set property of a resource.	N/A
DAV::take-ownership	Take ownership of a resource.	N/A
DAV::unlock	Unlock a resource locked using a WebDAV lock.	UPDATE
DAV::write-content	Modify the content of a resource.	UPDATE

[1] Note the colon (:) as part of the namespace name. DAV: is the namespace itself, *not* a prefix. A prefix commonly used for namespace DAV: is dav, but this is only conventional. dav is not a predefined prefix for Oracle XML DB.

Table 27–2 (Cont.) Atomic Privileges

Atomic Privilege	Description	Database Counterpart
DAV::write-properties	Modify the properties of a resource. Lock or unlock a resource. Modifiable properties include Author, DisplayName, Language, CharacterSet, ContentType, SBResExtra, Owner, OwnerID, CreationDate, Modification Date, ACL, ACLOID, Lock, and Locktoken.	UPDATE
xdb:link	Allow creation of links from a resource.	INSERT
xdb:link-to	Allow creation of links to a resource.	N/A
xdb:read-acl	Read the ACL of a resource.	SELECT
xdb:read-contents	Read the contents of a resource.	SELECT
xdb:read-properties	Read the properties of a resource.	SELECT
xdb:resolve	Traverse a folder (for folders only).	SELECT
xdb:unlink	Allow deletion of links from a resource.	DELETE
xdb:unlink-from	Allow deletion of links to a resource.	N/A
xdb:update-acl	Change the contents of the resource ACL.	UPDATE
xdb:write-acl-ref	Change the ACLOID of a resource.	UPDATE

Aggregate Privileges

Table 27–3 lists the aggregate privileges and the atomic privileges of which each is composed.

Table 27–3 Aggregate Privileges

Aggregate Privilege	Component Atomic Privileges
DAV::all	All atomic DAV privileges.
xdb:all	All atomic DAV privileges plus xdb:link-to.
DAV::bind	xdb:link
DAV::unbind	xdb:unlink
DAV::read	xdb:read-properties, xdb:read-contents, xdb:resolve
DAV::read-acl	xdb:read-acl
DAV::write	DAV::write-content, DAV::write-properties, xdb:link, xdb:unlink, xdb:unlink-from
DAV::write-acl	xdb:write-acl-ref, xdb:update-acl
DAV::update	DAV::write-content, DAV::write-properties
xdb:update	DAV::write-properties, DAV::write-content

ACLs and ACEs

An access control list (ACL) is a standard security mechanism that is used in some languages, such as Java, and some operating systems, such as Microsoft Windows. ACLs are also a part of the WebDAV standard. ACLs are used to protect resources, which in the case of Oracle Database can be either resources (files and folders) in Oracle XML DB Repository.

Repository resources can be accessed using WebDAV, and their protecting ACLs act as WebDAV ACLs. Each repository resource is protected by some ACL. ACLs that protect a resource are enforced no matter how the resource is accessed, whether by WebDAV, SQL, or any other way.

When a new resource is created in Oracle XML DB Repository, by default the ACL on its parent folder is used to protect the resource. After the resource is created, a new ACL can be set on it.

ACLs in Oracle Database are XML documents that are validated against the Oracle Database ACL XML schema, which is located in Oracle XML DB Repository at `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/acl.xsd`. ACLs are themselves stored and managed as resources in the repository.

Before a principal performs an operation on ACL-protected data, the user privileges for the protected data are checked. The set of privileges checked depends on the operation to be performed.

Aggregate privileges are composed of other privileges. When an ACL is stored, the aggregate privileges it refers to act as sets of pointers to their component privileges.

All ACLs are stored in table **`XDB$ACL`**, which is owned by database schema (user account) `XDB`. This is an XML schema-based `XMLType` table. Each row in this table (and therefore each ACL) has a system-generated object identifier (**OID**) that can be accessed as a column named **`OBJECT_ID`**.

Each Oracle XML DB Repository resource has a property named **`ACLOID`**. The `ACLOID` stores the OID of the ACL that protects the resource. An ACL is itself a resource, and the `XMLRef` property of an ACL, for example, `/sys/acls/all_all_acl.xml`, is a `REF` to the row in table `XDB$ACL` that contains the content of the ACL. These two properties form the link between table `XDB$RESOURCE`, which stores Oracle XML DB resources, and table `XDB$ACL`.

See Also:

- Appendix A, "Oracle-Supplied XML Schemas and Examples" for the ACL XML schema
- *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

System ACLs

Some ACLs are predefined and supplied with Oracle Database. They are referred to as **system ACLs**.

There is only one ACL that is self-protected, that is, protected by its own contents. It is the **bootstrap ACL**, a system ACL that is located in Oracle XML DB Repository at `/sys/acls/bootstrap_acl.xml`. The bootstrap ACL grants `READ` privilege to all users. It also grants `FULL ACCESS` to database roles `XDBADMIN` (the Oracle XML DB administrator) and `DBA`. Database role `XDBADMIN` is particularly useful for users who must register global XML schemas.

Other system ACLs include the following. Each is protected by the bootstrap ACL.

- **`all_all_acl.xml`** – Grants all privileges to all users.
- **`all_owner_acl.xml`** – Grants all privileges to the owner of the resource.
- **`ro_all_acl.xml`** – Grants read privileges to all users.

System ACLs use the file-naming convention *<privilege>*`_`*<users>*`_acl.xml`, where *<privilege>* represents the privilege granted, and *<users>* represents the users that

are granted access to the resource. When you define your own ACLs, you can use any names you like.

See Also: "Local and Global XML Schemas" on page 17-11

ACL and ACE Evaluation

Privileges are checked before a principal is allowed to access a repository resource that is protected by one or more ACLs. This check is done by evaluating the protecting ACLs for that principal, in order. For each such ACL, the ACEs in it that apply to the principal are examined, in order.

If one ACE grants a certain privilege to the current user and another ACE denies that privilege to the user, then a conflict arises. There are two possible ways to manage conflicts among ACEs for the same principal.

- The default behavior, termed **`ace-order`**, is to use only the *first* ACE that occurs for a given principal. Additional ACEs for that principal have no effect. In this case, *ACE order is relevant*.
- You can, however, configure the database to use an alternate behavior, **`deny-trumps-grant`**. In this case, any ACE with child `deny` for a given principal denies permission to that principal, whether or not there are other ACEs for that principal that have a `grant` child. In this case, `deny` always takes precedence over `grant`, and *ACE order is irrelevant*.

You can configure ACL evaluation behavior by setting configuration parameter **`acl-evaluation-method`**, in configuration file `xdbconfig.xml`, to either `ace-order` or `deny-trumps-grant`. The default configuration file specifies `ace-method`, but the default value for element `acl-evaluation-method`, used when no method is given, is `deny-trumps-grant`.

Note: In releases prior to Oracle Database 11g Release 1, only one ACL evaluation behavior was available: `deny-trumps-grant` (though it was not specified in the configuration file).

The change to use `ace-order` as the default behavior has important consequences for upgrading and downgrading between database versions. See "Upgrade or Downgrade of an Existing Oracle XML DB Installation" on page 35-1.

ACL Validation

When an ACL is created, it is validated against the XML schema for ACLs, and some correctness tests are run, such as ensuring that start and end dates for ACEs are in chronological order. There is no complete check at ACL creation time of relations among ACLs.

Such a complete check of ACL correctness is called **ACL validity** checking, but it is not to be confused with its XML *schema* validity. For an ACL to be valid (as an ACL), it must also be XML schema-valid, but the converse does not hold.

A full ACL validity check is made at run time, whenever an ACL is evaluated to check whether a principal has the proper privileges for some operation. If this check finds that the ACL is invalid, then all privileges that the ACL would grant are *denied* to the specified principals.

Element invert: Complement the Principals in an ACE

It is sometimes more convenient to define a set of principals by complementing another set of principals—that is the purpose of ACE element `invert`. Instead of listing each of the principals that you want to include, wrap the list of principals that you want to exclude with element `invert`.

In Example 27–3, the first ACE denies privilege `privilege1` to all principals except `IntranetUsers`. Because (by default) ACEs are considered in the order they appear, all subsequent ACEs are overridden by the first ACE, so principal `NonIntraNetUser` is denied privilege `privilege1` in spite of the explicit grant.

Example 27–3 Complementing a Set of Principals with Element invert

```
<acl description="invert ACL"
     xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
     xmlns:dav="DAV:"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                         http://xmlns.oracle.com/xdb/acl.xsd">
  <extends-from type="simple" href="/sys/acls/parent_acl.xml"/>
  <ace>
    <grant>false</grant>
    <invert><principal>dav:owner</principal></invert>
    <privilege><read-contents/></privilege>
  </ace>
  <ace>
    <grant>true</grant>
    <principal>GERONIMO</principal>
    <privilege><read-contents/></privilege>
  </ace>
</acl>
```

Working with Access Control Lists (ACLs)

Oracle Database access control lists (ACLs) are themselves (file) resources in Oracle XML DB Repository, so all of the access methods that operate on repository resources also apply to ACLs. In addition, there are several APIs specific to ACLs in PL/SQL package `DBMS_XDB_REPOS`. Those procedures and functions let you use PL/SQL to access Oracle XML DB security mechanisms, check user privileges based on a particular ACL, and list the set of privileges the current user has for a particular ACL and resource.

See Also: Chapter 35, "Administration of Oracle XML DB"

Creating an ACL Using DBMS_XDB_REPOS.CREATERESOURCE

Example 27–4 creates an ACL as file resource `/TESTUSER/acl1.xml`. If applied to a resource, this ACL grants all privileges to the owner of the resource.

Example 27–4 Creating an ACL Using CREATERESOURCE

```
DECLARE
  b BOOLEAN;
BEGIN
  b := DBMS_XDB_REPOS.createFolder('/TESTUSER');
  b := DBMS_XDB_REPOS.createResource(
         '/TESTUSER/acl1.xml',
```

```
          '<acl description="myacl"
                xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                xmlns:dav="DAV:"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                    http://xmlns.oracle.com/xdb/acl.xsd">
             <ace>
               <grant>true</grant>
               <principal>dav:owner</principal>
               <privilege>
                 <dav:all/>
               </privilege>
             </ace>
           </acl>',
          'http://xmlns.oracle.com/xdb/acl.xsd',
          'acl');
END;
```

Note: Before performing any operation that uses an ACL file resource that was created during the current transaction, you must perform a `COMMIT` operation. Until you do that, an ORA-22881 "dangling REF" error is raised whenever you use the ACL file.

Retrieving an ACL Document, Given its Repository Path

Example 27–5 shows how to retrieve an ACL document, given its location in Oracle XML DB Repository.

Example 27–5 Retrieving an ACL Document, Given its Repository Path

```
SELECT a.OBJECT_VALUE FROM RESOURCE_VIEW rv, XDB.XDB$ACL a
  WHERE ref(a)
        = XMLCast(XMLQuery('declare default element namespace
                            "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                            fn:data(/Resource/XMLRef)'
                           PASSING rv.RES RETURNING CONTENT)
                  AS REF XMLType)
    AND equals_path(rv.RES, '/TESTUSER/acl1.xml') = 1;

OBJECT_VALUE
--------------------------------------------------------------------------------
<acl description="myacl" xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="
DAV:" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="
http://xmlns.oracle.com/xdb/acl.xsd                                    http://xm
lns.oracle.com/xdb/acl.xsd" shared="true">
  <ace>
    <grant>true</grant>
    <principal>dav:owner</principal>
    <privilege>
      <dav:all/>
    </privilege>
  </ace>
</acl>
```

Setting the ACL of a Resource

Example 27–6 creates resource `/TESTUSER/po1.xml` and sets its ACL to `/TESTUSER/acl1.xml` using PL/SQL procedure `DBMS_XDB_REPOS.setACL`.

Example 27–6 Setting the ACL of a Resource

```
DECLARE
  b BOOLEAN;
BEGIN
  b := DBMS_XDB_REPOS_REPOS.createResource('/TESTUSER/po1.xml', 'Hello');
END;
/

CALL DBMS_XDB_REPOS_REPOS.setACL('/TESTUSER/po1.xml', '/TESTUSER/acl1.xml');
```

Deleting an ACL

Example 27–7 illustrates how to delete an ACL using procedure `DBMS_XDB_REPOS.deleteResource`. It deletes the ACL created in Example 27–4.

Example 27–7 Deleting an ACL

```
CALL DBMS_XDB_REPOS_REPOS.deleteResource('/TESTUSER/acl1.xml');
```

If a resource is being protected by an ACL that you want to delete, change the ACL of that resource before deleting the ACL.

Updating an ACL

You can update an ACL using any of the standard ways of updating resources. In particular, since an ACL is an XML document, you can use Oracle SQL/XML function `XMLQuery` with XQuery Update to manipulate ACLs. You must `COMMIT` after making any ACL changes.

Oracle XML DB ACLs are *cached*, for fast evaluation. When a transaction that updates an ACL is committed, the modified ACL is picked up by existing database sessions, after the timeout specified in the Oracle XML DB configuration file, `xdbconfig.xml`. The XPath location for this timeout parameter is `/xdbconfig/sysconfig/acl-max-age`. The value is expressed in seconds. Sessions initiated after the ACL is modified use the new ACL without any delay.

If an ACL resource is updated with non-ACL content, the same rules apply as for deletion. Thus, if any resource is being protected by an ACL that is being updated, you must first change the ACL.

> **See Also:** "Updating XML Data" on page 5-26 for information about the Oracle SQL functions used here to update XML data

You can use FTP or WebDAV to update an ACL. For more details on how to use these protocols, see Chapter 28, "Repository Access Using Protocols". You can update an ACL or an access control entry (ACE) using `RESOURCE_VIEW`.

Example 27–8 uses SQL/XML function `XMLQuery` together with XQuery Update to update the ACL `/TESTUSER/acl1.xml` by replacing it entirely. The effect is to replace the principal value `DAV::owner` by `TESTUSER`, because the rest of the replacement ACL is the same as it was before.

Example 27–8 Updating (Replacing) an Access Control List

```
UPDATE RESOURCE_VIEW r
 SET r.RES =
   XMLQuery(
     'declare namespace r="http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
      declare namespace a="http://xmlns.oracle.com/xdb/acl.xsd"; (: :)
```

```
                    copy $i := $p1 modify
                      (for $j in $i/r:Resource/r:Contents/a:acl
                       return replace node $j with $p2)
                     return $i'
                    PASSING r.RES AS "p1",
                            '<acl description="myacl"
                                  xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                                  xmlns:dav="DAV:"
                                  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                                  xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                                      http://xmlns.oracle.com/xdb/acl.xsd">
                               <ace>
                                 <grant>true</grant>
                                 <principal>TESTUSER</principal>
                                 <privilege><dav:all/></privilege>
                               </ace>
                             </acl>' AS "p2"
                   RETURNING CONTENT)
                 WHERE equals_path(r.RES, '/TESTUSER/acl1.xml') = 1;
```

Example 27–9 uses XQuery Update to append an ACE to an existing ACL. The ACE gives privileges `read-properties` and `read-contents` to user `HR`.

Example 27–9 Appending ACEs to an Access Control List

```
UPDATE RESOURCE_VIEW r
  SET r.RES =
    XMLQuery('declare namespace r="http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
              declare namespace a="http://xmlns.oracle.com/xdb/acl.xsd"; (: :)
              copy $i := $p1 modify
                (for $j in $i/r:Resource/r:Contents/a:acl
                 return insert nodes $p2 as last into $j)
              return $i'
             PASSING r.RES AS "p1",
                     XMLType('<ace xmlns="http://xmlns.oracle.com/xdb/acl.xsd">
                                 <grant>true</grant>
                                 <principal>HR</principal>
                                 <privilege>
                                   <read-properties/>
                                   <read-contents/>
                                 </privilege>
                               </ace>') as "p2"
             RETURNING CONTENT)
  WHERE equals_path(r.RES, '/TESTUSER/acl1.xml') = 1;
```

Example 27–10 uses Oracle SQL function `deleteXML` to delete an ACE from an ACL. The first ACE is deleted.

Example 27–10 Deleting an ACE from an Access Control List

```
UPDATE RESOURCE_VIEW r
  SET r.RES =
    XMLQuery('declare namespace r="http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
              declare namespace a="http://xmlns.oracle.com/xdb/acl.xsd"; (: :)
              copy $i := $p modify delete nodes $i/r:Resource/r:Contents/a:acl/a:ace[1]
              return $i'
             PASSING r.RES AS "p" RETURNING CONTENT)
  WHERE equals_path(r.RES, '/TESTUSER/acl1.xml') = 1;
```

Retrieving the ACL Document that Protects a Given Resource

Example 26–2 illustrates how to use function DBMS_XDB_REPOS.getACLDocument to retrieve the ACL document that protects a given resource.

Example 27–11 Retrieving the ACL Document for a Resource

```
SELECT XMLSerialize(DOCUMENT DBMS_XDB_REPOS.getACLDocument('/TESTUSER/po1.xml')
                    AS CLOB)
  FROM DUAL;

XMLSERIALIZE(DOCUMENTDBMS_XDB_REPOS.GETACLDOCUMENT('/TESTUSER/PO1.XML')ASCLOB)
--------------------------------------------------------------------------------
<acl description="myacl" xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="
DAV:" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="
http://xmlns.oracle.com/xdb/acl.xsd                                    http://x
mlns.oracle.com/xdb/acl.xsd">
  <ace>
    <grant>true</grant>
    <principal>TESTUSER</principal>
    <privilege>
      <dav:all/>
    </privilege>
  </ace>
  <ace xmlns="http://xmlns.oracle.com/xdb/acl.xsd">
    <grant>true</grant>
    <principal>HR</principal>
    <privilege>
      <read-properties/>
      <read-contents/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

> **See Also:** Example 26–2, "Using DBMS_XDB_REPOS.GETACLDOCUMENT" on page 26-4

Retrieving Privileges Granted to the Current User for a Particular Resource

Example 27–12 illustrates how to retrieve privileges granted to the current user using function DBMS_XDB_REPOS.getPrivileges.

Example 27–12 Retrieving Privileges Granted to the Current User for a Particular Resource

```
SELECT XMLSerialize(DOCUMENT DBMS_XDB_REPOS.getPrivileges('/TESTUSER/po1.xml')
                    AS CLOB)
  FROM DUAL;

XMLSERIALIZE(DOCUMENTDBMS_XDB_REPOS.GETPRIVILEGES('/TESTUSER/PO1.XML')ASCLOB)
--------------------------------------------------------------------------------
<privilege xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:xsi="http://www.w3.
org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl
.xsd http://xmlns.oracle.com/xdb/acl.xsd DAV: http://xmlns.oracle.com/xdb/dav.xs
d" xmlns:xdbacl="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:">
  <read-acl/>
  <dav:execute/>
  <read-contents/>
```

```
  <update-acl/>
  <dav:write-content/>
  <dav:read-current-user-privilege-set/>
  <link-to/>
  <resolve/>
  <dav:lock/>
  <unlink-from/>
  <write-config/>
  <dav:write-properties/>
  <dav:unlock/>
  <link/>
  <write-acl-ref/>
  <read-properties/>
  <dav:take-ownership/>
  <unlink/>
</privilege>

1 row selected.
```

Checking Whether the Current User Has Privileges on a Resource

Example 27–13 illustrates how to use function `DBMS_XDB_REPOS.checkPrivileges` to check whether the current user has a given set of privileges on a resource. This function returns a nonzero value if the user has the privileges.

Example 27–13 Checking If a User Has a Certain Privileges on a Resource

```
SELECT DBMS_XDB_REPOS.checkPrivileges(
         '/TESTUSER/po1.xml',
         XMLType('<privilege
                     xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                     xmlns:dav="DAV:"
                     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                         http://xmlns.oracle.com/xdb/acl.xsd">
                   <read-contents/>
                   <read-properties/>
                 </privilege>'))
  FROM DUAL;

DBMS_XDB_REPOS.CHECKPRIVILEGES('/TESTUSER/PO1.XML',
--------------------------------------------------
                                                 1

1 row selected.
```

Example 27–13 checks to see if the access privileges `read-contents` and `read-properties` have been granted to the current user on resource `/TESTUSER/po1.xml`. The positive-integer return value shows that they have.

Checking Whether a User Has Privileges Using the ACL and Resource Owner

Function `DBMS_XDB_REPOS.ACLCheckPrivileges` is typically used by applications that must perform ACL evaluation on their own, before allowing a user to perform an operation.

Example 27–14 checks whether the ACL `/TESTUSER/acl1.xml` grants the privileges `read-contents` and `read-properties` to the current user, `sh`. The second argument, `TESTUSER`, is the user that is substituted for `DAV::owner` in the ACL when checking.

Since user sh does *not* match any of the users granted the specified privileges, the return value is zero.

Example 27–14 Checking User Privileges Using ACLCheckPrivileges

```
CONNECT sh
Enter password: <password>

Connected.

SELECT DBMS_XDB_REPOS.ACLCheckPrivileges(
         '/TESTUSER/acl1.xml',
         'TESTUSER',
         XMLType('<privilege
                     xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                     xmlns:dav="DAV:"
                     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                         http://xmlns.oracle.com/xdb/acl.xsd">
                   <read-contents/>
                   <read-properties/>
                 </privilege>'))
  FROM DUAL;

DBMS_XDB_REPOS.ACLCHECKPRIVILEGES('/TESTUSER/ACL1.XML','TESTUSER',
----------------------------------------------------------------------
                                                                     0

1 row selected.
```

Retrieving the Path of the ACL that Protects a Given Resource

Example 27–15 retrieves the path of the ACL that protects a given resource, by using a RESOURCE_VIEW query. The query uses the fact that the XMLRef and ACLOID elements of the resource form the link between an ACL and a resource.

Example 27–15 Retrieving the Path of the ACL that Protects a Given Resource

```
SELECT rv1.ANY_PATH
  FROM RESOURCE_VIEW rv1
  WHERE
    XMLCast(XMLQuery('declare default element namespace
                      "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                      fn:data(/Resource/XMLRef)'
                     PASSING rv1.RES RETURNING CONTENT)
            AS REF XMLType)
    = make_ref(XDB.XDB$ACL,
               (SELECT XMLCast(XMLQuery('declare default element namespace
                                         "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                                         fn:data(/Resource/ACLOID)'
                                        PASSING rv2.RES RETURNING CONTENT)
                               AS REF XMLType)
                  FROM RESOURCE_VIEW rv2
                  WHERE equals_path(rv2.RES, '/TESTUSER/po1.xml') = 1));

ANY_PATH
------------------
/TESTUSER/acl1.xml
```

Example 27–15 retrieves the path to an ACL, given a resource protected by the ACL. The ACLOID of a protected resource (r) stores the OID of the ACL resource (a) that protects it. The REF of the ACL resource is the same as that of the object identified by the protected-resource ACLOID.

The REF of the resource ACLOID can be obtained using Oracle SQL function make_ref, which returns a REF to an object-table row with a given OID.

In this example, make_ref returns a REF to the row of table XDB$ACL whose OID is the /Resource/ACLOID for the resource /TESTUSER/po1.xml. The inner query returns the ACLOID of the resource. The outer query returns the path to the corresponding ACL.

Retrieving the Paths of All Resources Protected by a Given ACL

Example 27–16 retrieves the paths of all resources protected by a given ACL.

Example 27–16 Retrieving the Paths of All Resources Protected by a Given ACL

```
SELECT rv1.ANY_PATH
  FROM RESOURCE_VIEW rv1
  WHERE make_ref(XDB.XDB$ACL,
                 XMLCast(XMLQuery('declare default element namespace
                                   "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                                   fn:data(/Resource/ACLOID)'
                                  PASSING rv1.RES RETURNING CONTENT)
                         AS REF XMLType))
       = (SELECT XMLCast(XMLQuery('declare default element namespace
                                   "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                                   fn:data(/Resource/XMLRef)'
                                  PASSING rv2.RES RETURNING CONTENT)
                          AS REF XMLType)
            FROM RESOURCE_VIEW rv2
            WHERE equals_path(rv2.RES, '/TESTUSER/acl1.xml') = 1);

ANY_PATH
-----------------
/TESTUSER/po1.xml

1 row selected.
```

Example 27–16 retrieves the paths to the resources whose ACLOID REF matches the REF of the ACL resource whose path is /TESTUSER/acl1.xml. Function make_ref returns the resource ACLOID REF.

The inner query retrieves the REF of the specified ACL. The outer query selects the paths of the resources whose ACLOID REF matches the REF of the specified ACL.

ACL Caching

Since ACLs are checked for each access to the data they protect, the performance of the ACL check operation is critical to the performance of such data, including Oracle XML DB Repository resources. In Oracle XML DB, the required performance for this repository operation is achieved by employing several caches.

ACLs are saved in a cache that is shared by all sessions in the database instance. When an ACL is updated, its entry in the cache is invalidated, together with all objects dependent on it. The next time the ACL is used, a new copy of it is brought into the cache. Oracle recommends that you share ACLs among resources as much as possible.

There is a session-specific cache of privileges granted to a given user by a given ACL. The entries in this cache have a time out (in seconds) specified by the element <acl-max-age> in the Oracle XML DB configuration file (xdbconfig.xml). For maximum performance, set this timeout as large as possible. But note that there is a trade-off here: the greater the timeout, the longer it takes for current sessions to pick up an updated ACL.

Oracle XML DB also maintains caches to improve performance when using ACLs that have LDAP principals (LDAP groups or users). The goal of these caches is to minimize network communication with the LDAP server. One is a shared cache that maps LDAP GUIDs to the corresponding LDAP nicknames and Distinguished Names (DNs). This is used when an ACL document is being displayed (or converted to CLOB or VARCHAR2 values from an XMLType instance). To purge this cache, use procedure DBMS_XDBZ.purgeLDAPCache. The other cache is session-specific and maps LDAP groups to their members (nested membership). Note that whenever Oracle XML DB encounters an LDAP group for the first time (in a session) it gets the nested membership of that group from the LDAP server. Hence it is best to use groups with as few members and levels of nesting as possible.

Repository Resources and Database Table Security

Resources in Oracle XML DB Repository are of two types:

- LOB-based (content is stored in a LOB which is part of the resource). Access is determined only by the ACL that protects the resource.
- REF-based (content is XML and is stored in a database table). Users must have the appropriate privilege for the underlying table or view where the XML content is stored in addition to ACL permissions for the resource.

Since the content of a REF-based resource can be stored in a table, it is possible to access this data directly using SQL queries on the table. A **uniform** access control mechanism is one where the privileges needed for access are independent of the method of access (for example, FTP, HTTP, or SQL). To provide a uniform security mechanism using ACLs, the underlying table must first be **hierarchy-enabled**, before resources that reference the rows in the table are inserted into Oracle XML DB.

The default tables produced by XML schema registration are hierarchy-enabled. Enabling hierarchy is the default behavior when you register an XML schema with Oracle XML DB. You can also enable hierarchy after registration, using procedure DBMS_XDBZ.enable_hierarchy.

Enabling hierarchy on a resource table does the following:

- Adds two hidden columns to store the ACLOID and the OWNER of the resources that reference the rows in the table.
- Adds a row-level security (RLS) policy to the table, which checks the ACL whenever a SELECT, UPDATE, or DELETE operation is executed on the table.
- Creates a database trigger, called the **path-index trigger**, that ensures that the last-modified information for a resource is updated whenever the corresponding row is updated in the XMLType table where the content is stored.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about procedure `DBMS_XMLSCHEMA.registerSchema`
- *Oracle Database PL/SQL Packages and Types Reference* for information about procedure `DBMS_XDBZ.enable_hierarchy`

In any given table, it is possible that only some of the objects are mapped to Oracle XML DB resources. Only those objects that are mapped undergo ACL checking, but *all* of the objects have table-level security.

Note: You cannot hide data in `XMLType` tables from other users if *out-of-line* storage of is used. Out-of-line data is *not* protected by ACL security.

Optimization: Do not enforce acl-based security if you do not need it

ACL-based security provides control of access to XML content document-by-document, rather than just table-by-table. When you call PL/SQL procedure `DBMS_XMLSCHEMA.register_chema`, the tables it creates have ACL-based security enabled, by default.

One effect of this is that when the XML content of such a table is accessed using a SQL statement, a call to `sys_checkACL` is automatically added to the query `WHERE` clause, to ensure that the ACL security that was defined is enforced at the SQL level.

Enforcing ACL-based security adds overhead to the SQL query, however. If ACL-based security is *not* required, then use procedure `DBMS_XDBZ.disable_hierarchy` to turn *off* ACL checking.

When ACL-based security is enabled for an `XMLType` table, the execution plan output for a query of that table contains a filter similar to the following:

```
3 - filter(SYS_CHECKACL("ACLOID","OWNERID",xmltype(''<privilege
              xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
              xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
              xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
              http://xmlns.oracle.com/xdb/acl.xsd
              DAV:http://xmlns.oracle.com/xdb/dav.xsd">
                        <read-properties/><read-contents/></privilege>''))=1)
```

In this example, the filter checks that the user performing the SQL query has `read-contents` privilege on each of the documents to be accessed.

After calling `DBMS_XDBZ.disable_hierarchy`, an execution plan of the same query does not show `SYS_CHECKACL` in the filter.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for information about procedure `DBMS_XDBZ.disable_hierarchy`

Integration Of Oracle XML DB with LDAP

This section discusses allowing Lightweight Directory Access Protocol (LDAP) users to use the features of Oracle XML DB, including ACLs. The typical scenario is a single, shared database schema (user), to which multiple LDAP users are mapped. This mapping is maintained in the Oracle Internet Directory. End users can log into the database using their LDAP username and password. They are then automatically

mapped to the corresponding shared database schema. (Users can log in using SQL or any of the supported Oracle XML DB protocols.) The implicit ACL resolution is based on the current LDAP user and the corresponding LDAP group membership information.

Before you can use LDAP users and groups (also known as LDAP roles) as principals in Oracle XML DB ACLs, the following prerequisites must be satisfied:

- An Oracle Internet Directory must be set up, and the database must be registered with it.
- SSL authentication must be set up between the database and the Oracle Internet Directory.
- A database user must be created that corresponds to the shared database schema.
- The LDAP users must be created and mapped in the Oracle Internet Directory to the shared database schema.
- The LDAP groups must be created and their members must be specified.
- ACLs must be defined for the LDAP groups and users, and they must be used to protect the repository resources to be accessed by the LDAP users.

See Also:

- *Oracle Fusion Middleware Administrator's Guide for Oracle Internet Directory*
- *Oracle Database Security Guide* for information about setting up SSL authentication
- *Oracle Database Enterprise User Security Administrator's Guide* for information about using shared database schemas for enterprise (LDAP) users

Example 27–17 shows an ACL for an LDAP user. Element `<principal>` contains the full *distinguished name* of the LDAP user – in this case, `cn=user1,ou=Americas,o=oracle,l=redwoodshores,st=CA,c=US`.

Example 27–17 ACL Referencing an LDAP User

```
<acl description="/public/txmlacl1/acl1.xml"
     xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                         http://xmlns.oracle.com/xdb/acl.xsd">
  <ace principalFormat="DistinguishedName">
    <grant>true</grant>
    <principal>cn=user1,ou=Americas,o=oracle,l=redwoodshores,st=CA,c=US
    </principal>
    <privilege>
      <dav:all/>
    </privilege>
  </ace>
</acl>
```

See Also: *Oracle Fusion Middleware Administrator's Guide for Oracle Internet Directory* for the format of an LDAP user distinguished name

Example 27–18 shows an ACL for an LDAP group. Element `<principal>` contains the full distinguished name of the LDAP group.

Example 27–18 ACL Referencing an LDAP Group

```
<acl xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                         http://xmlns.oracle.com/xdb/acl.xsd">
  <ace principalFormat="DistinguishedName">
    <grant>true</grant>
    <principal>cn=grp1,ou=Americas,o=oracle,l=redwoodshores,st=CA,c=US</principal>
    <privilege>
      <dav:read/>
    </privilege>
  </ace>
</acl>
```

> **See Also:** *Oracle Fusion Middleware Administrator's Guide for Oracle Internet Directory* for the format of an LDAP group distinguished name

28

Repository Access Using Protocols

This chapter describes how to access Oracle XML DB Repository data using FTP, HTTP(S)/WebDAV protocols.

This chapter contains these topics:

Overview of Oracle XML DB Protocol Server

As described in Chapter 2, "Getting Started with Oracle XML DB" and Chapter 21, "Accessing Oracle XML DB Repository Data", Oracle XML DB Repository provides a hierarchical data repository in the database, designed for XML. Oracle XML DB Repository maps path names (or URLs) onto database objects of `XMLType` and provides management facilities for these objects.

Oracle XML DB also provides the Oracle XML DB *protocol server*. This supports standard Internet protocols, FTP, WebDAV, and HTTP(S), for accessing its hierarchical repository or file system. Note that HTTPS provides *secure* access to Oracle XML DB Repository.

These protocols can provide direct access to Oracle XML DB for many users without having to install additional software. The user names and passwords to be used with the protocols are the same as those for SQL*Plus. Enterprise users are also supported. Database administrators can use these protocols and resource APIs such as `DBMS_XDB_REPOS` to access Oracle Automatic Storage Management (Oracle ASM) files and folders in the repository virtual folder `/sys/asm`.

> **See Also:** Chapter 21, "Accessing Oracle XML DB Repository Data" for more information about accessing repository information, and restrictions on that access

Note:

- When accessing virtual folder `/sys/asm` using Oracle XML DB protocols, you must log in with the privileges of role `DBA` but as a user other than `SYS`.
- Oracle XML DB protocols are *not* supported on EBCDIC platforms.

Session Pooling

Oracle XML DB protocol server maintains a shared pool of sessions. Each protocol connection is associated with one session from this pool. After a connection is closed the session is put back into the shared pool and can be used to serve later connections.

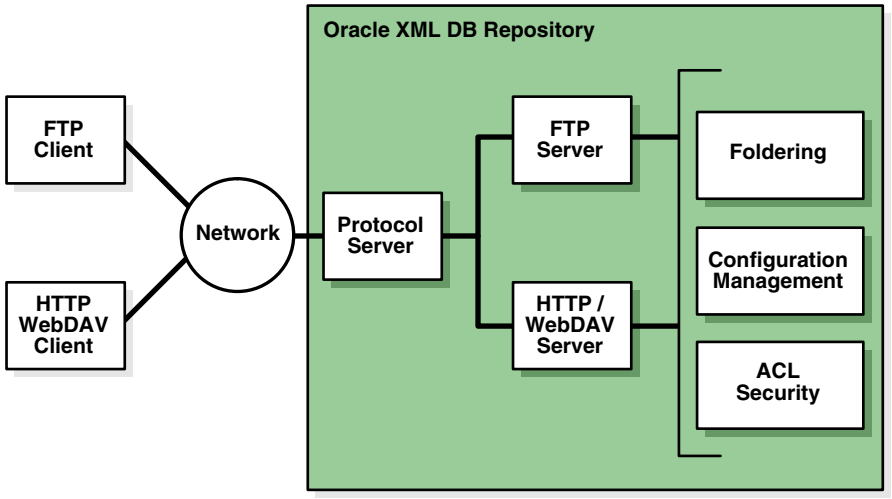
Session pooling improves performance of HTTP(S) by avoiding the cost of re-creating session states, especially when using HTTP 1.0, which creates new connections for each request. For example, a couple of small files can be retrieved by an existing HTTP/1.1 connection in the time necessary to create a database session. You can tune the number of sessions in the pool by setting session-pool-size in the Oracle XML DB configuration file, `xdbconfig.xml`, or disable it by setting pool size to zero.

Session pooling can affect users writing *Java servlets*, because other users can see session state initialized by another request for a different user. Hence, servlet writers should only use session memory, such as Java static variables, to hold data for the entire application rather than for a particular user. State for each user must be stored in the database or in a lookup table, rather than assuming that a session only exists for a single user.

> **See Also:** Chapter 32, "How to Write Oracle XML DB Applications in Java"

Figure 28–1 illustrates the Oracle XML DB protocol server components and how they are used to access files in Oracle XML DB Repository and other data. Only the relevant components of the repository are shown

Figure 28–1 Oracle XML DB Architecture: Protocol Server



Oracle XML DB Protocol Server Configuration Management

Oracle XML DB protocol server uses configuration parameters stored in `xdbconfig.xml` to initialize its startup state and manage session level configuration. The following section describes the protocol-specific configuration parameters that you can configure in the Oracle XML DB configuration file. The session pool size and timeout parameters cannot be changed dynamically, that is, you must restart the database in order for these changes to take effect.

> **See Also:** "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4

Configuration of Protocol Server Parameters

Figure 28–1 shows the parameters common to all protocols. All parameter names in this table, except those starting with `/xdbconfig`, are relative to the following XPath in the Oracle XML DB configuration schema:

```
/xdbconfig/sysconfig/protocolconfig/common
```

- *FTP-specific parameters* – Table 28–2 shows the FTP-specific parameters. These are relative to the following XPath in the Oracle XML DB configuration schema:

  ```
  /xdbconfig/sysconfig/protocolconfig/ftpconfig
  ```

- *HTTP(S)/WebDAV specific parameters, except servlet-related parameters* – Table 28–3 shows the HTTP(S)/WebDAV-specific parameters. These parameters are relative to the following XPath in the Oracle XML DB configuration schema:

  ```
  /xdbconfig/sysconfig/protocolconfig/httpconfig
  ```

> **See Also:**
>
> - Chapter 35, "Administration of Oracle XML DB" for more information about the configuration file `xdbconfig.xml`
> - "xdbconfig.xsd: XML Schema for Configuring Oracle XML DB" on page A-17
> - "Configuring Default Namespace to Schema Location Mappings" on page 35-10 for more information about the `schemaLocation-mappings` parameter
> - "Configuring XML File Extensions" on page 35-12 for more information about the `xml-extensions` parameter

For examples of the usage of these parameters, see the configuration file, `xdbconfig.xml`.

Table 28–1 Common Protocol Configuration Parameters

Parameter	Description
`extension-mappings/mime-mappings`	Specifies the mapping of file extensions to mime types. When a resource is stored in Oracle XML DB Repository, and its mime type is not specified, this list of mappings is used to set its mime type.

Table 28–1 (Cont.) Common Protocol Configuration Parameters

Parameter	Description
`extension-mappings/lang-mappings`	Specifies the mapping of file extensions to languages. When a resource is stored in Oracle XML DB Repository, and its language is not specified, this list of mappings is used to set its language.
`extension-mappings/encoding-mappings`	Specifies the mapping of file extensions to encodings. When a resource is stored in Oracle XML DB Repository, and its encoding is not specified, this list of mappings is used to set its encoding.
`xml-extensions`	Specifies the list of filename extensions that are treated as XML content by Oracle XML DB.
`session-pool-size`	Maximum number of sessions that are kept in the protocol server session pool
`/xdbconfig/sysconfig/call-timeout`	If a connection is idle for this time (in hundredths of a second), then the shared server serving the connection is freed up to serve other connections.
`session-timeout`	Time (in hundredths of a second) after which a session (and consequently the corresponding connection) is terminated by the protocol server if the connection has been idle for that time. This parameter is used only if the specific protocol session timeout is not present in the configuration
`schemaLocation-mappings`	Specifies the default schema location for a given namespace. This is used if the instance XML document does not contain an explicit `xsi:schemaLocation` attribute.
`/xdbconfig/sysconfig/default-lock-timeout`	Time period after which a WebDAV lock on a resource becomes invalid. This could be overridden by a Timeout specified by the client that locks the resource.

Table 28–2 Configuration Parameters Specific to FTP

Parameter	Description
`buffer-size`	Size of the buffer, in bytes, used to read data from the network during an FTP `put` operation. Set `buffer-size` to larger values for higher `put` performance. There is a trade-off between `put` performance and memory usage. The value can be from 1024 to 1048496, inclusive. The default value is 8192.

Table 28–2 (Cont.) Configuration Parameters Specific to FTP

Parameter	Description
ftp-port	Port on which FTP server listens. By default, this is 0, which means that FTP is *disabled*. FTP is disabled by default because the FTP specification requires that passwords be transmitted in clear text, which can present a security hazard. To enable FTP, set this parameter to the FTP port to use, such as 2100.
ftp-protocol	Protocol over which the FTP server runs. By default, this is tcp.
ftp-welcome-message	A user-defined welcome message that is displayed whenever an FTP client connects to the server. If this parameter is empty or missing, then the following default welcome message is displayed: "Unauthorized use of this FTP server is prohibited and may be subject to civil and criminal prosecution."
host-name	Name used to access the host system. The value can be an IP address or a name that is mapped to an IP address using host naming (e.g., in file /etc/hosts on Linux). By default, the IP address returned by the operating system is used.
session-timeout	Time (in hundredths of a second) after which an FTP connection is terminated by the protocol server if the connection has been idle for that time.

Table 28–3 Configuration Parameters Specific to HTTP(S)/WebDAV (Except Servlet)

Parameter	Description
http-port	Port on which the HTTP(S)/WebDAV server listens, using protocol http-protocol. By default, this is 0, which means that HTTP is *disabled*. If this parameter is empty (<http-port/>), then the default value of 0 applies. An empty parameter is *not* recommended. This parameter *must* be present, whether or not it is empty. Otherwise, validation of xdbconfig.xml against XML schema xdbconfig.xsd fails. The value must be different from the value of http2-port. Otherwise, an error is raised.
http2-port	Port on which the HTTP(S)/WebDAV server listens, using protocol http2-protocol. This parameter is *optional*, but, if present, then http2-protocol must also be present. Otherwise, an error is raised. The value must be different from the value of http-port. Otherwise, an error is raised. An empty parameter (<http2-port/>) also raises an error.

Table 28–3 (Cont.) Configuration Parameters Specific to HTTP(S)/WebDAV (Except

Parameter	Description
`http-protocol`	Protocol over which the HTTP(S)/WebDAV server runs on port `http-port`. Must be either `TCP` or `TCPS`. This parameter *must* be present. Otherwise, validation of `xdbconfig.xml` against XML schema `xdbconfig.xsd` fails. An empty parameter (`<http-protocol/>`) also raises an error.
`http2-protocol`	Protocol over which the HTTP(S)/WebDAV server runs on port `http2-port`. Must be either `TCP` or `TCPS`. If this parameter is empty (`<http2-protocol/>`), then the default value of `TCP` applies. (An empty parameter is *not* recommended.) This parameter is *optional*, but, if present, then `http2-port` must also be present. Otherwise, an error is raised.
`session-timeout`	Time (in hundredths of a second) after which an HTTP(S) session (and consequently the corresponding connection) is terminated by the protocol server if the connection has been idle for that time.
`max-header-size`	Maximum size (in bytes) of an HTTP(S) header
`max-request-body`	Maximum size (in bytes) of an HTTP(S) request body
`webappconfig/welcome-file-list`	List of filenames that are considered welcome files. When an HTTP(S) `get` request for a container is received, the server first checks if there is a resource in the container with any of these names. If so, then the contents of that file are sent, instead of a list of resources in the container.
`default-url-charset`	The character set in which an HTTP(S) protocol server assumes incoming URL is encoded when it is not encoded in UTF-8 or the Content-Type field Charset parameter of the request.
`allow-repository-anonymous-access`	Indication of whether or not anonymous HTTP access to Oracle XML DB Repository data is allowed using an unlocked `ANONYMOUS` user account. The default value is `false`, meaning that unauthenticated access to repository data is *blocked*. See "Anonymous Access to Oracle XML DB Repository Using HTTP" on page 28-21.
`authentication`	The HTTP authentication mechanisms allowed. See "Configuration and Management of Authentication Mechanisms for HTTP" on page 28-9
`expire`	HTTP header that specifies the expiration date and time for a URL. See "Control of URL Expiration Time" on page 28-20.

Configuring Secure HTTP (HTTPS)

To enable Oracle XML DB Repository to use *secure* HTTP connections (HTTPS), a database administrator (DBA) must configure the database accordingly: configure parameters `http2-port` and `http2-protocol`, enable the HTTP Listener to use SSL, and enable launching of the TCPS Dispatcher. After doing this, the DBA must stop, then restart, the database and the listener.

> **See Also:** "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4 for information about configuring Oracle XML DB parameters

Enabling the HTTP Listener to Use SSL

A database administrator must carry out the following steps, to configure the HTTP Listener for SSL.

1. *Create a wallet for the server and import a certificate* – Use Oracle Wallet Manager to do the following:
   a. Create a wallet for the server.
   b. If a valid certificate with distinguished name (DN) of the server is not available, create a certificate request and submit it to a certificate authority. Obtain a valid certificate from the authority.
   c. Import a valid certificate with the distinguished name (DN) of the server into the server.
   d. Save the new wallet in *obfuscated* form, so that it can be opened without a password.

   > **See Also:** *Oracle Database Enterprise User Security Administrator's Guide* for information about how to create a wallet

2. *Specify the wallet location to the server* – Use Oracle Net Manager to do this. Ensure that the configuration is saved to disk. This step updates files `sqlnet.ora` and `listener.ora`.
3. *Disable client authentication* at the server, since most Web clients do not have certificates. Use Oracle Net Manager to do this. This step updates file `sqlnet.ora`.
4. *Add an `SSL_DH_anon` cipher suite to `SSL_CIPHER_SUITES`* – Use any of these:
   - `SSL_DH_anon_WITH_3DES_EDE_CBC_SHA`
   - `SSL_DH_anon_WITH_RC4_128_MD5`
   - `SSL_DH_anon_WITH_DES_CBC_SHA`

   This step updates file `sqlnet.ora`.
5. *Create a listening end point that uses TCP/IP with SSL* – Use Oracle Net Manager to do this. This step updates file `listener.ora`.

   > **See Also:** *Oracle Database Security Guide* for detailed information regarding steps 1 through 5

Enabling TCPS Dispatcher

A database administrator must edit the database `pfile` to enable launching of a TCPS dispatcher during database startup. Add the following line to the file, where *`SID`* is the SID of the database:

```
dispatchers=(protocol=tcps)(service=SIDxdb)
```

The database `pfile` location depends on your operating system, as follows:

- *MS Windows* – *PARENT*`/admin/orcl/pfile`, where *PARENT* is the parent folder of folder `ORACLE_HOME`
- *UNIX, Linux* – `$ORACLE_HOME/admin/$ORACLE_SID/pfile`

Using Listener Status to Check Port Configuration

You can use the TNS Listener command, `lsnrctl status`, to verify that HTTP(S) and FTP support has been enabled. Example 28–1 illustrates this.

Example 28–1 Listener Status with FTP and HTTP(S) Protocol Support Enabled

```
LSNRCTL for 32-bit Windows: Version 11.1.0.5.0 - Production on 20-AUG-2007 16:02:34

Copyright (c) 1991, 2007, Oracle.  All rights reserved.

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=IPC)(KEY=EXTPROC1521))) STATUS of the LISTENER
------------------------------------------------------------------------------------------
Alias                         LISTENER
Version                       TNSLSNR for 32-bit Windows: Version 11.1.0.5.0 - Beta
Start Date                    20-JUN-2007 15:35:40
Uptime                        0 days 16 hr. 47 min. 42 sec
Trace Level                   off
Security                      ON: Local OS Authentication
SNMP                          OFF
Listener Parameter File       C:\oracle\product\11.1.0\db_1\network\admin\listener.ora
Listener Log File             c:\oracle\diag\tnslsnr\quine-pc\listener\alert\log.xml

Listening Endpoints Summary...
(DESCRIPTION=(ADDRESS=(PROTOCOL=ipc)(PIPENAME=\\.\pipe\EXTPROC1521ipc)))
(DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=quine-pc.example.com)(PORT=1521)))
(DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=quine-pc.example.com)
             (PORT=21))(Presentation=FTP)(Session=RAW))
(DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=quine-pc.example.com)
             (PORT=443))(Presentation=HTTP)(Session=RAW))
Services Summary...
Service "orcl.example.com" has 1 instance(s).
  Instance "orcl", status READY, has 1 handler(s) for this service...
Service "orclXDB.example.com" has 1 instance(s).
  Instance "orcl", status READY, has 1 handler(s) for this service...
Service "orcl_XPT.example.com" has 1 instance(s).
  Instance "orcl", status READY, has 1 handler(s) for this service...
The command completed successfully
```

See Also: Chapter 28, "Repository Access Using Protocols"

Configuring Protocol Port Parameters after Database Consolidation

In a multitenant container database (CDB), protocol server port numbers distinguish the plugged-in pluggable databases (PDBs): each such database must have unique port numbers. To avoid port conflicts and to resolve any port conflicts that might result from consolidation, a database administrator must proceed as follows:

1. Use PL/SQL function `DBMS_XDB_CONFIG.usedPort` to obtain the port numbers used by the other PDBs in the same CDB.

2. Use PL/SQL subprogram `DBMS_XDB_CONFIG.setFTPPort` or `DBMS_XDB_CONFIG.setHTTPPort`, as needed, to change each port number that conflicts so that it is unique.

Configuration and Management of Authentication Mechanisms for HTTP

Starting with 12*c* Release 1 (12.1.0.1), Oracle Database supports not only basic authentication but also digest access authentication, for accessing Oracle XML DB Repository.

Note that user credentials are case-sensitive. In particular, to be authenticated, a user name must exactly match the name as it was created (which by default is all uppercase).

Digest access authentication, also known as **digest authentication** provides encryption of user credentials (name, password, etc.) without the overhead of complete data encryption.

You can configure the authentication mechanism to use by setting element `authentication`, a child of element `httpconfig`, in configuration file `xdbconfig.xml`. Element `authentication` is optional. If absent then only basic authentication is used.

Element `authentication` has two possible child elements:

- Element `allow-mechanism` specifies an allowed mechanism: `basic`, `digest`, or `custom`. Use a separate `allow-mechanism` element to specify each mechanism you want to allow.
- Element `digest-auth` is optional. It specifies information for a digest mechanism. Its child element `nonce-timeout` specifies the number of seconds that a given nonce remains valid. The default value is 300 seconds.

  The default value is used if there is an `allow-mechanism` that specifies `digest` but there is no `digest-auth` element. A `digest-auth` element is ignored if there is no `allow-mechanism` that specifies `digest`.

HTTP requests are accepted for each `allow-mechanism` specified. Authentication challenges are presented in the order of the specified `allow-mechanism` types. For example, if both `digest` and `basic` are present, in that order, then a digest challenge is presented before a basic challenge. Oracle recommends that you *always* put a stronger authentication before a weaker one. (Digest authentication is stronger than basic authentication.)

See Also:

- "Upgrade or Downgrade of an Existing Oracle XML DB Installation" on page 35-1 for installation, upgrade, and downgrade considerations
- RFC2617, *HTTP Authentication: Basic and Digest Access Authentication*, `http://tools.ietf.org/html/rfc2617`

Nonces for Digest Authentication

A **nonce** is used with digest authentication. It is a unique string that the server generates each time it issues an HTTP 401 (unauthorized) response. Clients include the nonce in subsequent requests that they issue to the server. The server checks the nonce it receives from the client. If incorrect or if the `nonce-timeout` period has expired, the server can immediately refuse to authenticate.

(A client can use the same mechanism to authenticate the server: it can generate its own nonce. Both client and server can use this client nonce to help prevent particular plain-text attacks.)

A new nonce is created each time the server sends a digest challenge to a client. A nonce is based on a **nonce key**. The initial nonce key is generated randomly when you install or upgrade the database.

If you use digest authentication then Oracle also recommends that you create a new nonce key periodically, to ensure the integrity of the key. You use PL/SQL procedure `DBMS_XDB_ADMIN.createNonceKey` to do this.

Oracle XML DB Repository and File-System Resources

The protocol specifications, RFC 959 (FTP), RFC 2616 (HTTP), and RFC 2518 (WebDAV) implicitly assume an abstract, hierarchical file system on the server side. This is mapped to Oracle XML DB Repository. The repository provides:

- Name resolution.
- Security based on access control lists (ACLs). An ACL is a list of access control entries that determine which principals have access to a given resource or resources. See also Chapter 27, "Repository Access Control".
- The ability to store and retrieve any content. The repository can store both binary data input through FTP and XML schema-based documents.

See Also:

- http://www.ietf.org/rfc/rfc959.txt
- http://www.ietf.org/rfc/rfc2616.txt
- http://www.ietf.org/rfc/rfc2518.txt

Protocol Server Handles XML Schema-Based or Non-Schema-Based XML Documents

Oracle XML DB protocol server enhances the protocols by always checking if XML documents being inserted are based on XML schemas registered in Oracle XML DB Repository.

- If the incoming XML document specifies an XML schema, then the Oracle XML DB storage to use is determined by that XML schema. This functionality is especially useful when you must store XML documents object-relationally in the database using simple protocols like FTP or WebDAV instead of using SQL statements.
- If the incoming XML document is not XML schema-based, then it is stored as a binary document.

Event-Based Logging

In certain cases, it can be useful to log the requests received and responses sent by a protocol server. This can be achieved by setting event number `31098` to level `2`. To set this event, add the following line to your `init.ora` file and restart the database:

```
event="31098 trace name context forever, level 2"
```

Using FTP and Oracle XML DB Protocol Server

The following sections describe FTP features supported by Oracle XML DB.

Oracle XML DB Protocol Server: FTP Features

File Transfer Protocol (FTP) is one of the oldest and most popular protocols on the net. FTP is specified in RFC959 and provides access to heterogeneous file systems in a uniform manner. FTP works by providing well-defined commands (methods) for communication between the client and the server. The transfer of command messages and the return of status happens on a single connection. However, a new connection is opened between the client and the server for data transfer. With HTTP(S), commands and data are transferred using a single connection.

FTP is implemented by dedicated clients at the operating system level, file-system explorer clients, and browsers. FTP is typically session-oriented: a user session is created through an explicit logon, a number of files or directories are downloaded and browsed, and then the connection is closed.

Note: For security reasons, FTP is *disabled*, by default. This is because the IETF FTP protocol specification requires that passwords be transmitted in clear text. Disabling is done by configuring the FTP server port as zero (0). To enable FTP, set the `ftp-port` parameter to the FTP port to use, such as 2100.

See Also:

- RFC 959: FTP Protocol Specification – `http://www.ietf.org/rfc/rfc959.txt`
- "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4 for information about configuring parameters

FTP Features That Are Not Supported

Oracle XML DB implements FTP, as defined by RFC 959, with the *exception* of the following optional features:

- Record-oriented files, for example, only the `FILE` structure of the `STRU` method is supported. This is the most widely used structure for transfer of files. It is also the default specified by the specification. Structure mount is not supported.
- Append.
- Allocate. This pre-allocates space before file transfer.
- Account. This uses the insecure Telnet protocol.
- Abort.

Supported FTP Client Methods

For access to the repository, Oracle XML DB supports the following FTP client methods.

- `cdup` – change working directory to parent directory
- `cwd` – change working directory
- `dele` – delete file (not directory)
- `list`, `nlst` – list files in working directory
- `mkd` – create directory
- `noop` – do nothing (but timeout counter on connection is reset)

- `pasv`, `port` – establish a TCP data connection
- `pwd` – get working directory
- `quit` – close connection and quit FTP session
- `retr` – retrieve data using an established connection
- `rmd` – remove directory
- `rnfr`, `rnto` – rename file (two-step process: from file, to file)
- `stor` – store data using an established connection
- `syst` – get system version
- `type` – change data type: `ascii` or `image` binary types only
- `user`, `pass` – user login

See Also:

- "FTP Quote Methods" for supported FTP `quote` methods
- "Using FTP with Oracle ASM Files" on page 28-14 for an example of using FTP method `proxy`

FTP Quote Methods

Oracle Database supports several FTP `quote` methods, which provide information directly to Oracle XML DB.

- **`rm_r`** – Remove file or folder *<resource_name>*. If a folder, recursively remove all files and folders contained in *<resource_name>*.

  ```
  quote rm_r <resource_name>
  ```

- **`rm_f`** – Forcibly remove a resource.

  ```
  quote rm_f <resource_name>
  ```

- **`rm_rf`** – Combines `rm_r` and `rm_f`: Forcibly and recursively removes files and folders.

  ```
  quote rm_rf <resource_name>
  ```

- **`set_nls_locale`** – Specify the character-set encoding (*<charset_name>*) to be used for file and directory names in FTP methods (including names in method responses).

  ```
  quote set_nls_locale {<charset_name> | NULL}
  ```

  Only IANA character-set names can be specified for *<charset_name>*. If `nls_locale` is set to `NULL` or is not set, then the database character set is used.

- **`set_charset`** – Specify the character set of the data to be sent to the server.

  ```
  quote set_charset  {<charset_name> | NULL}
  ```

  The `set_charset` method applies to only *text* files, not binary files, as determined by the file-extension mapping to MIME types that is defined in configuration file `xdbconfig.xml`.

  If the parameter provided to `set_charset` is ***<charset_name>*** (*not* `NULL`), then it specifies the character set of the data.

If the parameter provided to `set_charset` is `NULL`, or if no `set_charset` command is given, then the *MIME type* of the data determines the character set for the data.

- If the MIME type is *not* `text/xml`), then the data is not assumed to be XML. The database character set is used.
- If the MIME type is **`text/xml`**, then the data represents an XML document.

  If a *byte order mark*[1] (BOM) is present in the XML document, then it determines the character set of the data.

  If there is *no* BOM, then:

  * If there is an *encoding declaration* in the XML document, then it determines the character set of the data.
  * If there is *no* encoding declaration, then the UTF-8 character set is used.

Uploading Content to Oracle XML DB Repository Using FTP

Example 28–2 shows commands issued and output generated when a standard command line FTP tool loads documents into Oracle XML DB Repository:

Example 28–2 Uploading Content to the Repository Using FTP

```
$ ftp mdrake-sun 2100
Connected to mdrake-sun.
220 mdrake-sun FTP Server (Oracle XML DB/Oracle Database 10g Enterprise Edition
Release 10.1.0.1.0 - Beta) ready.
Name (mdrake-sun:oracle10): QUINE
331 Password required for QUINE
Password: password
230 QUINE logged in
ftp> cd /source/schemas
250 CWD Command successful
ftp> mkdir PurchaseOrders
257 MKD Command successful
ftp> cd PurchaseOrders
250 CWD Command successful
ftp> mkdir 2002
257 MKD Command successful
ftp> cd 2002
250 CWD Command successful
ftp> mkdir "Apr"
257 MKD Command successful
ftp> put "Apr/AMCEWEN-20021009123336171PDT.xml"
"Apr/AMCEWEN-20021009123336171PDT.xml"
200 PORT Command successful
150 ASCII Data Connection
226 ASCII Transfer Complete
local: Apr/AMCEWEN-20021009123336171PDT.xml remote:
Apr/AMCEWEN-20021009123336171PDT.xml
4718 bytes sent in 0.0017 seconds (2683.41 Kbytes/s)
ftp> put "Apr/AMCEWEN-20021009123336271PDT.xml"
"Apr/AMCEWEN-20021009123336271PDT.xml"
200 PORT Command successful
150 ASCII Data Connection
226 ASCII Transfer Complete
local: Apr/AMCEWEN-20021009123336271PDT.xml remote:
```

[1] BOM is a Unicode-standard signature that indicates the order of the stream of bytes that follows it.

```
Apr/AMCEWEN-20021009123336271PDT.xml
4800 bytes sent in 0.0014 seconds (3357.81 Kbytes/s)
.....
ftp> cd "Apr"
250 CWD Command successful
ftp> ls -l
200 PORT Command successful
150 ASCII Data Connection
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 AMCEWEN-20021009123336171PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 AMCEWEN-20021009123336271PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 EABEL-20021009123336251PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 PTUCKER-20021009123336191PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 PTUCKER-20021009123336291PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SBELL-20021009123336231PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SBELL-20021009123336331PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SKING-20021009123336321PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SMCCAIN-20021009123336151PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SMCCAIN-20021009123336341PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 VJONES-20021009123336301PDT.xml
226 ASCII Transfer Complete
remote: -l
959 bytes received in 0.0027 seconds (349.45 Kbytes/s)
ftp> cd ".."
250 CWD Command successful
....
ftp> quit
221 QUIT Goodbye.
$
```

The key point demonstrated by Figure 28–3 and Example 28–2 is that neither Windows Explorer nor an FTP tool is aware that it is working with Oracle XML DB. Since the tools and Oracle XML DB both support open Internet protocols they work with each other out of the box.

Any tool that understands the WebDAV or FTP protocol can be used to create content managed by Oracle XML DB Repository. No additional software has to installed on the client or the mid-tier.

When the contents of the folders are viewed using a tool such as Windows Explorer or FTP, the length of any schema-based XML documents contained in the folder is shown as zero (0) bytes. This was designed as such for two reasons:

- It is not clear what the size of the document should be. Is it the size of the `CLOB` instance generated by printing the document, or the number of bytes required to store the objects used to persist the document inside the database?
- Regardless of which definition is chosen, calculating and maintaining this information is costly.

Using FTP with Oracle ASM Files

Oracle Automatic Storage Management (Oracle ASM) organizes database files into disk groups for simplified management and added benefits such as database mirroring and I/O balancing. Database administrators can use protocols and resource APIs to access Oracle ASM files in the Oracle XML DB repository *virtual folder* `/sys/asm`. All files in `/sys/asm` are binary.

Typical uses are listing, copying, moving, creating, and deleting Oracle ASM files and folders. Example 28–3 is an example of navigating the Oracle ASM virtual folder and listing the files in a subfolder.

The structure of the Oracle ASM virtual folder, `/sys/asm`, is described in Chapter 21, "Accessing Oracle XML DB Repository Data". In Example 28–3, the disk groups are `DATA` and `RECOVERY`; the database name is `MFG`; and the directories created for aliases are `dbs` and `tmp`. This example navigates to a subfolder, lists its files, and copies a file to the local file system.

Example 28–3 Navigating Oracle ASM Folders

```
ftp> open myhost 7777
ftp> user system
Password required for SYSTEM
Password: password
ftp> cd /sys/asm
ftp> ls
DATA
RECOVERY
ftp> cd DATA
ftp> ls
dbs
MFG
ftp> cd dbs
ftp> ls
t_dbl.f
t_axl.f
ftp> binary
ftp> get t_dbl.f, t_axl.f
ftp> put my_db2.f
```

In Example 28–3, after connecting to and logging onto database `myhost` (first four lines), FTP methods `cd` and `ls` are used to navigate and list folders, respectively. When in folder `/sys/asm/DATA/dbs`, FTP command `get` is used to copy files `t_db1.f` and `t_ax1.f` to the current folder of the local file system. Then, FTP command `put` is used to copy file `my_db2.f` from the local file system to folder `/sys/asm/DATA/dbs`.

Database administrators can copy Oracle Automatic Storage Management (Oracle ASM) files from *one database server to another* or between the database and a local file system. Example 28–4 shows copying between two databases. For this, the `proxy` FTP client method can be used, if available. The `proxy` method provides a *direct* connection to two different remote FTP servers.

Example 28–4 copies an Oracle ASM file from one database to another. Terms with the suffix `1` correspond to database `server1`. Terms with the suffix `2` correspond to database `server2`. Note that, depending on your FTP client, the passwords you type might be echoed on your screen. Take the necessary precautions so that others do not see these passwords.

Example 28–4 Transferring Oracle ASM Files Between Databases with FTP proxy Method

```
 1 ftp> open server1 port1
 2 ftp> user username1
 3 Password required for USERNAME1
 4 Password: password-for-username1
 5 ftp> cd /sys/asm/DATAFILE/MFG/DATAFILE
 6 ftp> proxy open server2 port2
 7 ftp> proxy user username2
 8 Password required for USERNAME2
 9 Password: password-for-username2
10 ftp> proxy cd /sys/asm/DATAFILE/MFG/DATAFILE
11 ftp> proxy put dbs2.f tmp1.f
```

```
12 ftp> proxy get dbs1.f tmp2.f
```

In Example 28–4:

- Line 1 opens an FTP control connection to the Oracle XML DB FTP server, `server1`.
- Lines 2–4 log the database administrator onto `server1` as `USERNAME1`.
- Line 5 navigates to `/sys/asm/DATAFILE/MFG/DATAFILE` on `server1`.
- Line 6 opens an FTP control connection to the second database server, `server2`. At this point, the FTP command `proxy ?` could be issued to see the available FTP commands on the secondary connection. (This is not shown.)
- Lines 7–9 log the database administrator onto `server2` as `USERNAME2`.
- Line 10 navigates to `/sys/asm/DATAFILE/MFG/DATAFILE` on `server2`.
- Line 11 copies Oracle ASM file `dbs2.f` from `server2` to Oracle ASM file `tmp1.f` on `server1`.
- Line 12 copies Oracle ASM file `dbs1.f` from `server1` to Oracle ASM file `tmp2.f` on `server2`.

Using FTP on the Standard Port Instead of the Oracle XML DB Default Port

You can use the Oracle XML DB configuration file, `xdbconfig.xml`, to configure FTP to listen on any port. By default, FTP listens on a non-standard, unprotected port. To use FTP on the standard port, 21, your database administrator must do the following:

1. (UNIX only) Use this shell command to ensure that the owner and group of executable file `tnslsnr` are `root`:

   ```
   % chown root:root $ORACLE_HOME/bin/tnslsnr
   ```

2. (UNIX only) Add the following entry to the listener file, `listener.ora`, where *`hostname`* is your host name:

   ```
   (DESCRIPTION =
     (ADDRESS = (PROTOCOL = TCP) (HOST = hostname) (PORT = 21))
     (PROTOCOL_STACK = (PRESENTATION = FTP) (SESSION = RAW)))
   ```

3. (UNIX only) Use shell command `id` to determine the *`user_id`* and *`group_id`* that were used to install Oracle Database. *`oracle_installation_user`* is the name of the user who installed the database.

   ```
   % id oracle_installation_user
   uid=user_id(oracle_installation_user) gid=group_id(dba)
   ```

4. (UNIX only) Stop, then restart the listener, using the following shell commands, where *`user_id`* and *`group_id`* are the UNIX user and group identifiers obtained in step 3.

   ```
   % lsnrctl stop
   % tnslsnr LISTENER -user user_id -group group_id &
   ```

   Use the ampersand (`&`), to execute the second command in the background. Do not use `lsnrctl start` to start the listener.

5. Use PL/SQL procedure `DBMS_XDB_CONFIG.setFTPPort` with `SYS as SYSDBA` to set the FTP port number to 21 in the Oracle XML DB configuration file, `xdbconfig.xml`.

```
SQL> exec DBMS_XDB_CONFIG.setFTPPort(21);
```

6. Force the database to reregister with the listener, using this SQL statement:

```
SQL> ALTER SYSTEM REGISTER;
```

7. Check that the listener is correctly configured, using this shell command:

```
% lsnrctl status
```

See Also:

- *Oracle Database Net Services Reference* for information about listener parameters and file `listener.ora`
- *Oracle Database Net Services Reference*, section "Port Number Limitations" for information about running on privileged ports

Using IPv6 IP Addresses with FTP

Starting with 11*g* Release 2 (11.2), Oracle Database supports the use of Internet Protocol Version 6, IPv6 (in addition to Internet Protocol Version 4). Example 28–5 shows how to make an FTP connection with the IPv6 address `2001::0db8:ffff:ffff:ffff`.

Example 28–5 FTP Connection Using IPv6

```
ftp> open 2001::0db8:ffff:ffff:ffff 1521
Connected to 2001::0db8:ffff:ffff:ffff.
220- xmlhost.example.com
Unauthorized use of this FTP server is prohibited and may be subject to civil
and criminal prosecution.
220- xmlhost.example.com FTP server (Oracle XML DB/Oracle Database) ready.
User (2001::0db8:ffff:ffff:ffff:(none)): username
331 pass required for USERNAME
Password: password-for-username
230 USERNAME logged in
ftp>
```

See Also: *Oracle Database Net Services Reference* for information about IPv6

FTP Server Session Management

Oracle XML DB protocol server also provides session management for this protocol. After a short wait for a new command, FTP returns to the protocol layer and the shared server is freed up to serve other connections. The duration of this short wait is configurable by changing parameter `call-timeout` in the Oracle XML DB configuration file. For high traffic sites, `call-timeout` should be shorter, so that more connections can be served. When new data arrives on the connection, the FTP server is re-invoked with fresh data. So, the long running nature of FTP does not affect the number of connections which can be made to the protocol server.

See Also: "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4 for information about configuring Oracle XML DB parameters

Handling Error 421. Modifying the Default Timeout Value of an FTP Session

If you are frequently disconnected from the server and must reconnect and traverse the entire directory before doing the next operation, you may need to modify the

default timeout value for FTP sessions. If the session is idle for more than this period, it gets disconnected. You can increase the timeout value (default = 6000 centiseconds) by modifying the configuration document as follows and then restart the database:

Example 28–6 Modifying the Default Timeout Value of an FTP Session

```
DECLARE
  newconfig XMLType;
BEGIN
SELECT XMLQuery('copy $i := $p1 modify
                   (for $j in $i/xdbconfig/sysconfig/protocolconfig/ftpconfig/session-timeout
                    return replace value of node $j with $p2)
                 return $i'
                PASSING DBMS_XDB_CONFIG.cfg_get() AS "p1", 123456789 AS "p2" RETURNING CONTENT)
  INTO newconfig FROM DUAL;
  DBMS_XDB_CONFIG.cfg_update(newconfig);
END;
/
COMMIT;
```

FTP Client Failure in Passive Mode

Do not use FTP in *passive mode* to connect remotely to a server that has `HOSTNAME` configured in `listener.ora` as `localhost` or `127.0.0.1`. If the `HOSTNAME` specified in server file `listener.ora` is `localhost` or `127.0.0.1`, then the server is configured for *local use only*. If you try to connect remotely to the server using FTP in passive mode, the FTP client fails. This is because the server passes IP address `127.0.0.1` (derived from `HOSTNAME`) to the client, which makes the client try to connect to itself, not to the server.

HTTP(S) and Oracle XML DB Protocol Server

Oracle XML DB implements HyperText Transfer Protocol (HTTP), HTTP 1.1 as defined in the RFC2616 specification.

Oracle XML DB Protocol Server: HTTP(S) Features

The Oracle XML DB HTTP(S) component in the Oracle XML DB protocol server implements the RFC2616 specification with the *exception* of the following optional features:

- `gzip` and compress transfer encodings
- byte-range headers
- The `TRACE` method (used for proxy error debugging)
- Cache-control directives (these require you to specify expiration dates for content, and are not generally used)
- TE, Trailer, Vary & Warning headers
- Weak entity tags
- Web common log format
- Multi-homed Web server

> **See Also:** RFC 2616, *HTTP 1.1 Protocol Specification*, http://www.ietf.org/rfc/rfc2616.txt

Supported HTTP(S) Client Methods

For access to the repository, Oracle XML DB supports the following HTTP(S) client methods.

- `OPTIONS` – get information about available communication options
- `GET` – get document/data (including headers)
- `HEAD` – get headers only, without document body
- `PUT` – store data in resource
- `DELETE` – delete resource

The semantics of these HTTP(S) methods is in accordance with WebDAV. Servlets and Web services may support additional HTTP(S) methods, such as `POST`.

> **See Also:** "WebDAV Client Methods Supported by Oracle XML DB" on page 28-24 for supported HTTP(S) client methods involving WebDAV

Using HTTP(S) on a Standard Port Instead of an Oracle XML DB Default Port

You can use the Oracle XML DB configuration file, `xdbconfig.xml`, to configure HTTP(S) to listen on any port. By default, HTTP(S) listens on a non-standard, unprotected port. To use HTTP or HTTPS on a standard port (80 for HTTP, 443 for HTTPS), your database administrator must do the following:

1. (UNIX only) Use this shell command to ensure that the owner and group of executable file `tnslsnr` are `root`:

   ```
   % chown root:root $ORACLE_HOME/bin/tnslsnr
   ```

2. (UNIX only) Add the following entry to the listener file, `listener.ora`, where *`hostname`* is your host name, and *`port_number`* is `80` for HTTP or `443` for HTTPS:

   ```
   (DESCRIPTION =
     (ADDRESS = (PROTOCOL = TCP) (HOST = hostname) (PORT = port_number))
     (PROTOCOL_STACK = (PRESENTATION = HTTP) (SESSION = RAW)))
   ```

3. (UNIX only) Use shell command `id` to determine the *`user_id`* and *`group_id`* that were used to install Oracle Database. *`oracle_installation_user`* is the name of the user who installed the database.

   ```
   % id oracle_installation_user
   uid=user_id(oracle_installation_user) gid=group_id(dba)
   ```

4. (UNIX only) Stop, then restart the listener, using the following shell commands, where *`user_id`* and *`group_id`* are the UNIX user and group identifiers obtained in step 3.

   ```
   % lsnrctl stop
   % tnslsnr LISTENER -user user_id -group group_id &
   ```

   Use the ampersand (`&`), to execute the second command in the background. Do not use `lsnrctl start` to start the listener.

5. Use PL/SQL procedure `DBMS_XDB_CONFIG.setHTTPPort` with `SYS as SYSDBA` to set the HTTP(S) port number to *`port_number`* in the Oracle XML DB configuration file `xdbconfig.xml`, where *`port_number`* is `80` for HTTP or `443` for HTTPS:

   ```
   SQL> exec DBMS_XDB_CONFIG.setHTTPPort(port_number);
   ```

6. Force the database to reregister with the listener, using this SQL statement:

```
SQL> ALTER SYSTEM REGISTER;
```

7. Check that the listener is correctly configured:

```
% lsnrctl status
```

See Also:

- *Oracle Database Net Services Reference* for information about listener parameters and file `listener.ora`
- *Oracle Database Net Services Reference*, section "Port Number Limitations" for information about running on privileged ports

Using IPv6 IP Addresses with HTTP(S)

Starting with 11g Release 2 (11.2), Oracle Database supports the use of Internet Protocol Version 6, IPv6 (in addition to Internet Protocol Version 4). IPv6 addresses in URLs are enclosed in brackets (`[]`). Here is an example:

```
http://[2001::0db8:ffff:ffff:ffff]:8080/
```

See Also: *Oracle Database Net Services Reference* for information about IPv6

HTTPS: Support for Secure HTTP

If properly configured, you can access Oracle XML DB Repository in a *secure* fashion, using HTTPS. See "Configuring Secure HTTP (HTTPS)" on page 28-7 for configuration information.

Note: If Oracle Database is installed on Microsoft Windows XP with *Service Pack 2* (SP2), then you must use HTTPS for WebDAV access to Oracle XML DB Repository, or else you must make appropriate modifications to the Windows XP Registry. For information about the latter, see `http://www.microsoft.com/technet/prodtechnol/winxppro/maintain/sp2netwk.mspx#XSLTsection129121120120`

Control of URL Expiration Time

Optional configuration parameter `expire` specifies an HTTP `Expires` header. This header acts as a directive to the HTTP client, to specify the expiration date and time for a URL.

If cached, the document targeted by a URL can be fetched from the client cache rather than from the server, until this expiration time has passed. After that time, the cache copy is out-of-date and a new copy must be obtained from the source (server).

The Oracle XML DB syntax for the `Expires` header, which is used in the `expire` configuration element, is a subset of the so-called alternate syntax defined for the `ExpiresDefault` directive of the Apache module `mod_expires`. See `http://httpd.apache.org/docs/2.0/mod/mod_expires.html#AltSyn` for that syntax.

These are the Oracle XML DB restrictions to the `ExpiresDefault` syntax:

- You cannot use `access` as the `<base>`. Only `now` and `modification` are allowed.

- The <type> values must appear in order of decreasing time period. For example, year must appear before, not after, month, since a year is a longer time period than a month.
- You can use at most one occurrence of each of the different <type> values. For example, you cannot have multiple year entries or multiple day entries.

Anonymous Access to Oracle XML DB Repository Using HTTP

Optional configuration parameter allow-repository-anonymous-access controls whether or not anonymous HTTP access to Oracle XML DB Repository data is allowed using an unlocked ANONYMOUS user account. The default value is false, meaning that unauthenticated access to repository data is *blocked*. To allow anonymous HTTP access to the repository, you must set this parameter to true, and unlock the ANONYMOUS user account.

Caution: There is an inherent *security risk* associated with allowing anonymous access to the repository.

Parameter allow-repository-anonymous-access does *not* control anonymous access to the repository using *servlets*. Each servlet has its own security-role-ref parameter value to control its access.

See Also:

- Table 28–3 on page 28-5 for information about parameter allow-repository-anonymous-access
- "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4 for information about configuring Oracle XML DB parameters
- "Configuration of Oracle XML DB Servlets" on page 32-3 for information about parameter security-role-ref

Use of Java Servlets with HTTP(S)

Oracle XML DB supports Java servlets. To use a Java servlet, it must be registered with a unique name in the Oracle XML DB configuration file, along with parameters to customize its action. It should be compiled, and loaded into the database. Finally, the servlet name must be associated with a pattern, which can be an extension such as *.jsp or a path name such as /a/b/c or /sys/*, as described in Java servlet application program interface (API) version 2.2.

While processing an HTTP(S) request, the path name for the request is matched with the registered patterns. If there is a match, then the protocol server invokes the corresponding servlet with the appropriate initialization parameters. For Java servlets, the existing Java Virtual Machine (JVM) infrastructure is used. This starts the JVM if need be, which in turn invokes a Java method to initialize the servlet, create response, and request objects, pass these on to the servlet, and run it.

See Also: Chapter 32, "How to Write Oracle XML DB Applications in Java"

Embedded PL/SQL Gateway

You can use the PL/SQL gateway to implement a Web application entirely in PL/SQL. There are two implementations of the PL/SQL gateway:

- *mod_plsql* – a plug-in of *Oracle HTTP Server* that lets you invoke PL/SQL stored procedures using HTTP(S). Oracle HTTP Server is a component of both Oracle Fusion Middleware and Oracle Database. Do not confuse Oracle HTTP Server with the HTTP component of the Oracle XML DB protocol server.
- the *embedded* PL/SQL gateway – a gateway implementation that runs in the Oracle XML DB HTTP listener.

With the PL/SQL gateway (either implementation), a Web browser sends an HTTP(S) request in the form of a URL that identifies a stored procedure and provides it with parameter values. The gateway translates the URL, calls the stored procedure with the parameter values, and returns output (typically HTML) to the Web-browser client.

Using the embedded PL/SQL gateway simplifies installation, configuration, and administration of PL/SQL based Web applications. The embedded gateway uses the Oracle XML DB protocol server, not Oracle HTTP Server. Its configuration is defined by the Oracle XML DB configuration file, `xdbconfig.xml`. However, the *recommended* way to configure the embedded gateway is to use the procedures in PL/SQL package `DBMS_EPG`, *not* to edit file `xdbconfig.xml`.

See Also:

- *Oracle Database Development Guide* for information on using and configuring the embedded PL/SQL gateway
- Chapter 35, "Administration of Oracle XML DB" for information on the configuration definition of the embedded gateway in `xdbconfig.xml`
- *Oracle Fusion Middleware Administrator's Guide for Oracle HTTP Server* for conceptual information about using the PL/SQL gateway
- *Oracle Fusion Middleware User's Guide for mod_plsql* for information about mod_plsql

Transmission of Multibyte Data From a Client

When a client sends multibyte data in a URL, RFC 2718 specifies that the client should send the URL using the `%HH` format, where `HH` is the hexadecimal notation of the byte value in UTF-8 encoding. The following are URL examples that can be sent to Oracle XML DB in an HTTP(S) or WebDAV context:

```
http://urltest/xyz%E3%81%82%E3%82%A2
http://%E3%81%82%E3%82%A2
http://%E3%81%82%E3%82%A2/abc%E3%81%86%E3%83%8F.xml
```

Oracle XML DB processes the requested URL, any URLs within an `IF` header, any URLs within the `DESTINATION` header, and any URLs in the `REFERRED` header that contains multibyte data.

The `default-url-charset` configuration parameter can be used to accept requests from some clients that use other, nonconforming, forms of URL, with characters that are not ASCII. If a request with such characters fails, try setting this value to the native character set of the client environment. The character set used in such URL fields must be specified with an IANA charset name.

`default-url-charset` controls the encoding for nonconforming URLs. It is not required to be set unless a nonconforming client that does not send the `Content-Type` charset is used.

See Also:

- RFC 2616, *HTTP 1.1 Protocol Specification*, `http://www.ietf.org/rfc/rfc2616.txt`
- "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4 for information about configuring Oracle XML DB parameters

Characters That Are Not ASCII in URLs

Characters that are not ASCII that appear in URLs passed to an HTTP server should be converted to `UTF-8` and escaped in the `%HH` format, where *HH* is the hexadecimal notation of the byte value. For flexibility, the Oracle XML DB protocol server interprets the incoming URLs by testing whether it is encoded in one of the following character sets in the order presented here:

- UTF-8
- Charset parameter of the `Content-Type` field of the request, if specified
- Character set, if specified, in the `default-url-charset` configuration parameter
- Character set of the database

See Also: "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4 for information about configuring Oracle XML DB parameters

Character Sets for HTTP(S)

The following sections describe how character sets are controlled for data transferred using HTTP(S).

Request Character Set The character set of the HTTP(S) request body is determined with the following algorithm:

- The Content-Type header is evaluated. If the Content-Type header specifies a charset value, the specified charset is used.
- The MIME type of the document is evaluated as follows:
  - If the MIME type is "`*/xml`", the character set is determined as follows:

    - If a BOM is present, then `UTF-16` is used.

    - If an encoding declaration is present, the specified encoding is used.

    - If neither a BOM nor an encoding declaration is present, `UTF-8` is used.
  - If the MIME type is text, `ISO8859-1` is used.
  - If the MIME type is neither "`*/xml`" nor `text`, the database character set is used.

There is a difference between HTTP(S) and SQL or FTP. For text documents, the default is ISO8859-1, as specified by the IETF.org *RFC 2616: HTTP 1.1 Protocol Specification*.

Response Character Set

The response generated by Oracle XML DB HTTP Server is in the character set specified in the `Accept-Charset` field of the request. `Accept-Charset` can have a list of character sets. Based on the q-value, Oracle XML DB chooses one that does not require conversion. This might not necessarily be the charset with the highest q-value. If Oracle XML DB cannot find one, then the conversion is based on the highest q-value.

WebDAV and Oracle XML DB

Web Distributed Authoring and Versioning (WebDAV) is an IETF standard protocol used to provide users with a file-system interface to Oracle XML Repository over the Internet. The most popular way of accessing a WebDAV server folder is through WebFolders using Microsoft Windows.

WebDAV is an extension to the HTTP 1.1 protocol that lets an HTTP server act as a file server. It lets clients perform remote Web content authoring through a coherent set of methods, headers, request body formats and response body formats. For example, a DAV-enabled editor can interact with an HTTP/WebDAV server as if it were a file system. WebDAV provides operations to store and retrieve resources, create and list contents of resource collections, lock resources for concurrent access in a coordinated manner, and to set and retrieve resource properties.

Oracle XML DB WebDAV Features

Oracle XML DB supports the following WebDAV features:

- Foldering, specified by RFC2518
- Access Control

WebDAV is a set of extensions to the HTTP(S) protocol that allow you to edit or manage your files on remote Web servers. WebDAV can also be used, for example, to:

- Share documents over the Internet
- Edit content over the Internet

> **See Also:** RFC 2518: WebDAV Protocol Specification, http://www.ietf.org/rfc/rfc2518.txt

WebDAV Features That Are Not Supported by Oracle XML DB

Oracle XML DB supports the contents of RFC2518, with the following exceptions:

- Lock-`NULL` resources create zero-length resources in the file system, and cannot be converted to folders.
- Methods `COPY`, `MOVE` and `DELETE` comply with section 2 of the Internet Draft titled 'Binding Extensions to WebDAV'.
- Depth-infinity locks

WebDAV Client Methods Supported by Oracle XML DB

For access to the repository, Oracle XML DB supports the following HTTP(S)/WebDAV client methods.

- `PROPFIND` (WebDAV-specific) – get properties for a resource
- `PROPPATCH` (WebDAV-specific) – set or remove resource properties
- `LOCK` (WebDAV-specific) – lock a resource (create or refresh a lock)
- `UNLOCK` (WebDAV-specific) – unlock a resource (remove a lock)

- `COPY` (WebDAV-specific) – copy a resource
- `MOVE` (WebDAV-specific) – move a resource
- `MKCOL` (WebDAV-specific) – create a folder resource (collection)

See Also:

- "Supported HTTP(S) Client Methods" on page 28-19 for additional supported HTTP(S) client methods
- "Privileges" on page 27-5 for information about WebDAV privileges
- "Adding Metadata Using WebDAV PROPPATCH" on page 29-8

WebDAV and Microsoft Windows XP SP2

For Microsoft Windows XP with *Service Pack 2* (SP2), you must use a secure connection (HTTPS) for WebDAV access to Oracle XML DB Repository, or else you must make appropriate modifications to the Windows XP Registry.

See Also:

- `http://www.microsoft.com/technet/prodtechnol/winxppro/maintain/sp2netwk.mspx#XSLTsection129121120120` for information about making necessary modifications to the Windows XP registry
- "Configuring Secure HTTP (HTTPS)" on page 28-7

Creating a WebFolder in Microsoft Windows Using Oracle XML DB and WebDAV

To create a WebFolder in Windows 2000, follow these steps:

1. **Start** > **My Network Places**.
2. Double-click **Add Network Place**.
3. Click **Next**.
4. Type the location of the folder, for example:

   `http://`*`Oracle_server_name`*`:`*`HTTP_port_number`*

   See Figure 28–2.
5. Click **Next**.
6. Enter any name to identify this WebFolder
7. Click **Finish**.

You can access Oracle XML DB Repository the same way that you access any Windows folder.

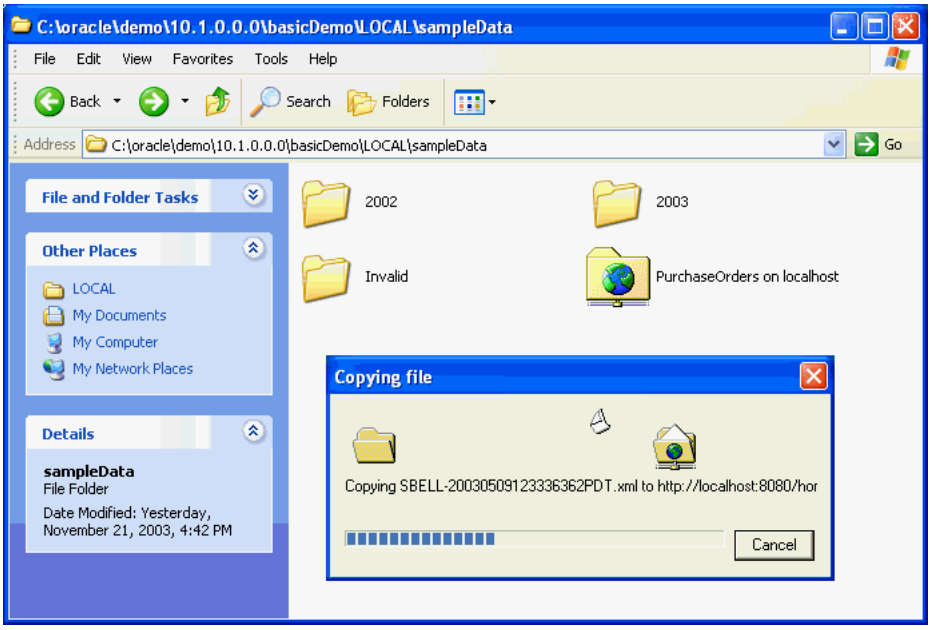
Figure 28–2 Creating a WebFolder in Microsoft Windows

Copying Files into Oracle XML DB Repository Using WebDAV

Figure 28–3 shows Windows Explorer used to insert a folder from the local hard drive into Oracle Database. Windows Explorer includes support for the WebDAV protocol. WebDAV extends the HTTP standard, adding additional verbs that allow an HTTP server to act as a file server.

When a Windows Explorer copy operation or FTP input command is used to transfer a number of documents into Oracle XML DB Repository, each `put` or `post` command is treated as a separate atomic operation. This ensures that the client does not get confused if one of the file transfers fails. It also means that changes made to a document through a protocol are visible to other users as soon as the request has been processed.

Figure 28–3 Copying Files into Oracle XML DB Repository



29

User-Defined Repository Metadata

This chapter describes how to create and use XML metadata, which you associate with XML data and store in Oracle XML DB Repository.

This chapter contains these topics:

Overview of Metadata and XML

Data that you use is often associated with additional information that is not part of the content. To process it in different ways, you can use such **metadata** to group or classify data. For example, you might have a collection of digital photographs, and you might associate metadata with each picture, such as information about the photographic characteristics (color composition, focal length) or context (location, kind of subject: landscape, people).

An Oracle XML DB repository **resource** is an XML document that contains both metadata and data. The data is the contents of element `Contents`. All other elements in the resource contain metadata. The data of a resource can be XML, but it need not be.

You can associate resources in the Oracle XML DB repository with metadata that you define. In addition to such *user-defined metadata*, each repository resource also has associated metadata that Oracle XML DB creates automatically and uses (transparently) to manage the resource. Such *system-defined metadata* includes properties such as the owner and creation date of each resource.

Except for system-defined metadata, you decide which resource information should be treated as data and which should be treated as metadata. For a photo resource, supplemental information about the photo is normally not considered to be part of the photo data, which is a binary image. For text, however, you sometimes have a choice of whether to include particular information in the resource contents (data) or keep it separate and associate it with the contents as metadata—that choice is often influenced by the applications that use or produce the data.

Kinds of Metadata – Uses of the Term

In addition to resource metadata (system-defined and user-defined), the term "metadata" is sometimes used to refer to the following:

- An XML *schema* is metadata that describes a class of XML documents.
- An XML *tag* (element or attribute name) is metadata that is used to label and organize the element content or attribute value.

You can associate metadata with an XML document that is the content of a repository resource in any of these ways:

- You can add additional XML elements containing the metadata information to the resource *contents*. For example, you could wrap digital image data in an XML document that also includes elements describing the photo. In this case, the data and its metadata are associated by being in the contents of the same resource. It is up to applications to separate the two and relate them correctly.
- You can add metadata information for a particular resource to the repository as the contents of a *separate resource*. In this case, it is up to applications to treat this resource as metadata and associate it with the data.
- You can add metadata information for a resource as repository *resource metadata*. In this case, Oracle XML DB recognizes the metadata as such. Applications can *discover* this metadata by querying the repository for it. They need not be informed separately of its existence and its association with the data.

See Also: "Oracle XML DB Repository Resources" on page 21-7

User-Defined Resource Metadata

Of these different ways of considering metadata, this chapter is about only the last of those just listed: *user-defined resource metadata*. Such metadata is itself *represented as XML*: it is XML data that is associated with other XML data, describing it or providing supplementary, related information.

User-defined metadata for resources can be either XML schema-based or not:

- Resource metadata that is *schema-based* is stored in separate (out-of-line) tables. These are related to the resource table by the resource OID, which is stored in the hidden object column `RESID` of the metadata tables.
- Resource metadata that is *not* schema-based is stored as part of the resource document in the resource table, `XDB.XDB$RESOURCE`.

You can take advantage of schema-based metadata, in particular, to perform efficient queries and DML operations on resources. In this chapter, you learn how to perform the following tasks involving schema-based resource metadata:

- Create and register an *XML schema* that defines the metadata for a particular kind of resource.
- *Add* metadata to a repository resource, and *update* (modify) such metadata.
- *Query* resource metadata to find associated content.
- *Delete* specific metadata associated with a resource and *purge* all metadata associated with a resource.

In addition, you learn how to add non-schema-based metadata to a resource.

You can generally use user-defined resource metadata just as you would use resource data. In particular, versioning and access control management apply.

Typical uses of resource metadata include workflow applications, enforcing user rights management, tracking resource ownership, and controlling resource validity dates.

Scenario: Metadata for a Photo Collection

To illustrate the use of schema-based resource metadata, this chapter uses metadata associated with photographic image files that are stored in repository resources. You can create any number of different kinds of metadata to be associated with the same resource. For image files, examples create metadata for information about both 1) the technical aspects of a photo and 2) the photo subject or the uses to which a photo might be put. These two kinds of associated metadata are used to query photo resources.

XML Schemas to Define Resource Metadata

This section first defines the metadata to associate with each photo resource using XML Schema. An XML schema is created and registered for each kind (technique, category) of metadata.

The XML schema in Example 29–1 defines metadata used to describe the technical aspects of a photo image file. It uses PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema` to register the XML schema. To identify this schema as defining repository resource *metadata*, it uses `ENABLE_HIERARCHY_RESMETADATA` as the value for parameter `enableHierarchy`. Resource contents (data) are defined by using value `ENABLE_HIERARCHY_CONTENTS` (the default value), instead.

The properties defined in Example 29–1 are the image height, width, color depth, title, and brief description.

Example 29–1 Registering an XML Schema for Technical Photo Information

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL       => 'imagetechnique.xsd',
    SCHEMADOC       => '<xsd:schema targetNamespace="inamespace"
                                xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                                xmlns:xdb="http://xmlns.oracle.com/xdb"
                                xmlns="inamespace">
                          <xsd:element name="ImgTechMetadata"
                                       xdb:defaultTable="IMGTECHMETADATATABLE">
                            <xsd:complexType>
                              <xsd:sequence>
                                <xsd:element name="Height"      type="xsd:float"/>
                                <xsd:element name="Width"       type="xsd:float"/>
                                <xsd:element name="ColorDepth"  type="xsd:integer"/>
                                <xsd:element name="Title"       type="xsd:string"/>
                                <xsd:element name="Description" type="xsd:string"/>
                              </xsd:sequence>
                            </xsd:complexType>
                          </xsd:element>
                        </xsd:schema>',
    enableHierarchy => DBMS_XMLSCHEMA.ENABLE_HIERARCHY_RESMETADATA);
END;
/
```

The XML schema in Example 29–2 defines metadata used to categorize a photo image file: to describe its content or possible uses. This simple example defines a single, general property for classification, named `Category`.

Example 29–2 Registering an XML Schema for Photo Categorization

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL       => 'imagecategories.xsd',
    SCHEMADOC       => '<xsd:schema targetNamespace="cnamespace"
                                    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                                    xmlns:xdb="http://xmlns.oracle.com/xdb"
                                    xmlns="cnamespace">
                          <xsd:element name="ImgCatMetadata"
                                       xdb:defaultTable="IMGCATMETADATATABLE">
                            <xsd:complexType>
                              <xsd:sequence>
                                <xsd:element name="Categories"
                                             type="CategoriesType"/>
                              </xsd:sequence>
                            </xsd:complexType>
                          </xsd:element>
                          <xsd:complexType name="CategoriesType">
                            <xsd:sequence>
                              <xsd:element name="Category" type="xsd:string"
                                           maxOccurs="unbounded"/>
                            </xsd:sequence>
                          </xsd:complexType>
                        </xsd:schema>',
    enableHierarchy => DBMS_XMLSCHEMA.ENABLE_HIERARCHY_RESMETADATA);
END;
/
```

Notice that there is nothing in the XML schema definitions of metadata that restrict that information to being associated with any particular kind of data. You are free to associate any type of metadata with any type of resource. And multiple types of metadata can be associated with the same resource.

Notice, too, that the XML schema does not, by itself, define its associated data as being metadata—it is the schema *registration* that makes this characterization, through `enableHierarchy` value `ENABLE_HIERARCHY_RESMETADATA`. If the same schema were registered instead with `enableHierarchy` value `ENABLE_HIERARCHY_CONTENTS` (the default value), then it would define not metadata for resources, but resource *contents* with the same information. The same XML schema cannot be registered more than once under the same name.

Addition, Modification, and Deletion of Resource Metadata

You can add, update, and delete user-defined resource metadata in the following ways:

- Use PL/SQL procedures in package `DBMS_XDB_REPOS`:
  - `appendResourceMetadata` – add metadata to a resource
  - `updateResourceMetadata` – modify resource metadata
  - `deleteResourceMetadata` – delete specific metadata from a resource
  - `purgeResourceMetadata` – delete *all* metadata from a resource
- Use SQL DML statements `INSERT`, `UPDATE`, and `DELETE` to update the resource directly
- Use WebDAV protocol method `PROPPATCH`

You use SQL DM statements and WebDAV method PROPPATCH to update or delete metadata in the same way as you add metadata. If you supply a complete Resource element for one of these operations, then keep in mind that each resource metadata property must be a child (not just a descendant) of element Resource—if you want multiple metadata elements of the same kind, you must collect them as children of a single parent metadata element. The order among such top-level user-defined resource metadata properties is unimportant and is not necessarily maintained by Oracle XML DB.

The separate PL/SQL procedures in package DBMS_XDB_REPOS are similar in their use. Each can be used with either XML schema-based or non-schema-based metadata. Some forms (signatures) of some of the procedures apply only to schema-based metadata. Procedures appendResourceMetadata and deleteResourceMetadata are illustrated here with examples.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information about the procedures in PL/SQL package DBMS_XDB_REPOS

Adding Metadata Using APPENDRESOURCEMETADATA

You can use procedure DBMS_XDB_REPOS.appendResourceMetadata to add user-defined metadata to resources.

Example 29–3 creates a photo resource and adds XML schema-based metadata of type ImgTechMetadata to it, recording the technical information about the photo.

Example 29–3 Add Metadata to a Resource – Technical Photo Information

```
DECLARE
  returnbool BOOLEAN;
BEGIN
  returnbool := DBMS_XDB_REPOS.createResource(
                  '/public/horse_with_pig.jpg',
                  bfilename('MYDIR', 'horse_with_pig.jpg'));
  DBMS_XDB_REPOS.appendResourceMetadata(
    '/public/horse_with_pig.jpg',
    XMLType('<i:ImgTechMetadata
                xmlns:i="inamespace"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xsi:schemaLocation="inamespace imagetechnique.xsd">
              <Height>1024</Height>
              <Width>768</Width>
              <ColorDepth>24</ColorDepth>
              <Title>Pig Riding Horse</Title>
              <Description>Picture of a pig riding a horse on the beach,
taken outside hotel window.</Description>
            </i:ImgTechMetadata>'));
END;
/
```

Example 29–4 adds metadata of type ImgTechMetadata to the same resource as Example 29–3, placing the photo in several user-defined content categories.

Example 29–4 Add Metadata to a Resource – Photo Content Categories

```
BEGIN
  DBMS_XDB_REPOS.appendResourceMetadata(
    '/public/horse_with_pig.jpg',
    XMLType('<c:ImgCatMetadata
```

```
                  xmlns:c="cnamespace"
                  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                  xsi:schemaLocation="cnamespace imagecategories.xsd">
                <Categories>
                  <Category>Vacation</Category>
                  <Category>Animals</Category>
                  <Category>Humor</Category>
                  <Category>2005</Category>
                </Categories>
              </c:ImgCatMetadata>'));
END;
/

PL/SQL procedure successfully completed.

SELECT * FROM imgcatmetadatatable;

SYS_NC_ROWINFO$
--------------------------------------------------------------------------------
<c:ImgCatMetadata xmlns:c="cnamespace" xmlns:xsi="http://www.w3.org/2001/XMLSche
ma-instance" xsi:schemaLocation="cnamespace imagecategories.xsd">
  <Categories>
    <Category>Vacation</Category>
    <Category>Animals</Category>
    <Category>Humor</Category>
    <Category>2005</Category>
  </Categories>
</c:ImgCatMetadata>

1 row selected.
```

Deleting Metadata Using DELETERESOURCEMETADATA

You can use procedure `DBMS_XDB_REPOS.deleteResourceMetadata` to delete specific metadata associated with a resource. To delete *all* of the metadata associated with a resource, you can use procedure `DBMS_XDB_REPOS.purgeResourceMetadata`.

Example 29–5 deletes the category metadata that was added to the photo resource in Example 29–4. By default, both the resource link (`REF`) to the metadata and the metadata table identified by that link are deleted. An optional parameter can be used to specify that only the link is to be deleted. The metadata table is then left as is but becomes unrelated to the resource. In this example, the default behavior is used.

Example 29–5 Delete Specific Metadata from a Resource

```
BEGIN
  DBMS_XDB_REPOS.deleteResourceMetadata('/public/horse_with_pig.jpg',
                                        'cnamespace',
                                        'ImgCatMetadata');
END;
/

PL/SQL procedure successfully completed.

SELECT * FROM imgcatmetadatatable;

no rows selected
```

Adding Metadata Using SQL DML

An alternative to using procedure DBMS_XDB_REPOS.appendResourceMetadata to add, update, or delete resource metadata is to update the RESOURCE_VIEW directly using DML statements INSERT and UPDATE.

Adding resource metadata in this way is illustrated by Example 29–6. It shows how to accomplish the same thing as Example 29–3 by inserting the metadata directly into RESOURCE_VIEW using SQL statement UPDATE. Other SQL DML statements may be used similarly.

Example 29–6 Adding Metadata to a Resource Using DML with RESOURCE_VIEW

```
UPDATE RESOURCE_VIEW
  SET RES =
        insertChildXML(
          RES,
          '/r:Resource',
          'c:ImgCatMetadata',
          XMLType('<c:ImgCatMetadata
                      xmlns:c="cnamespace"
                      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                      xsi:schemaLocation="cnamespace imagecategories.xsd">
                    <Categories>
                      <Category>Vacation</Category>
                      <Category>Animals</Category>
                      <Category>Humor</Category>
                      <Category>2005</Category>
                    </Categories>
                  </c:ImgCatMetadata>'),
          'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
           xmlns:c="cnamespace"')
  WHERE equals_path(RES, '/public/horse_with_pig.jpg') = 1;
/

SELECT * FROM imgcatmetadatatable;

SYS_NC_ROWINFO$
--------------------------------------------------------------------------------
<c:ImgCatMetadata xmlns:c="cnamespace" xmlns:xsi="http://www.w3.org/2001/XMLSche
ma-instance" xsi:schemaLocation="cnamespace imagecategories.xsd">
  <Categories>
    <Category>Vacation</Category>
    <Category>Animals</Category>
    <Category>Humor</Category>
    <Category>2005</Category>
  </Categories>
</c:ImgCatMetadata>

1 row selected.
```

The following query extracts the inserted metadata using RESOURCE_VIEW, rather than directly using metadata table imgcatmetadatatable. (The result is shown here pretty-printed, for clarity.)

```
SELECT XMLQuery('declare namespace r
                   = "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                 declare namespace c
                   = "cnamespace"; (: :)
                 /r:Resource/c:ImgCatMetadata'
                PASSING RES RETURNING CONTENT)
```

```
  FROM RESOURCE_VIEW
  WHERE equals_path(RES, '/public/horse_with_pig.jpg') = 1;

XMLQUERY('DECLARENAMESPACER="HTTP://XMLNS.ORACLE.COM/XDB/XDBRESOURCE.XSD";(::)DE
--------------------------------------------------------------------------------
<c:ImgCatMetadata xmlns:c="cnamespace"
                  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                  xsi:schemaLocation="cnamespace imagecategories.xsd">
  <Categories>
    <Category>Vacation</Category>
    <Category>Animals</Category>
    <Category>Humor</Category>
    <Category>2005</Category>
  </Categories>
</c:ImgCatMetadata>

1 row selected.
```

Adding Metadata Using WebDAV PROPPATCH

Another alternative to using procedure `DBMS_XDB_REPOS.appendResourceMetadata` to add resource metadata is to use WebDAV method `PROPPATCH`. This is illustrated in Example 29–7. You can update and delete metadata similarly.

Example 29–7 shows how to accomplish the same thing as Example 29–4 by inserting the metadata using WebDAV method `PROPPATCH`. Using appropriate tools, your application creates such a `PROPPATCH` WebDAV request and sends it to the WebDAV server for processing.

To update user-defined metadata, you proceed in the same way. To *delete* user-defined metadata, the WebDAV request is similar, but it has `D:remove` in place of `D:set`.

Example 29–7 Adding Metadata Using WebDAV PROPPATCH

```
PROPPATCH /public/horse_with_pig.jpg HTTP/1.1
Host: www.example.com
Content-Type: text/xml; charset="utf-8"
Content-Length: 609
Authorization: Basic dGRhZHhkYl9tZXRhOnRkYWR4ZGJfbWV0YQ==
Connection: close

<?xml version="1.0" encoding="utf-8" ?>
<D:propertyupdate xmlns:D="DAV:" xmlns:Z="http://www.w3.com/standards/z39.50/">
  <D:set>
    <D:prop>
      <c:ImgCatMetadata
          xmlns:c="cnamespace"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="cnamespace imagecategories.xsd">
        <Categories>
          <Category>Vacation</Category>
          <Category>Animals</Category>
          <Category>Humor</Category>
          <Category>2005</Category>
        </Categories>
      </c:ImgCatMetadata>
    </D:prop>
  </D:set>
</D:propertyupdate>
```

Querying XML Schema-Based Resource Metadata

When you register an XML schema using the `enableHierarchy` value `ENABLE_HIERARCHY_RESMETADATA`, an additional column, `RESID`, is added automatically to the `XMLType` tables used to store the metadata. This column stores the object identifier (OID) of the resource associated with the metadata. You can use column `RESID` when querying metadata, to join the metadata with the associated data.

You can query metadata in these ways:

- Query `RESOURCE_VIEW` for the metadata. For example:

```
SELECT count(*) FROM RESOURCE_VIEW
  WHERE
    XMLExists(
      'declare namespace r
         = "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
       declare namespace c
         = "cnamespace"; (: :)
       /r:Resource/c:ImgCatMetadata/Categories/Category[text()="Vacation"]'
      PASSING RES);

  COUNT(*)
----------
         1

1 row selected.
```

- Query the XML schema-based table for the user-defined metadata directly, and join this metadata back to the resource table, identifying which resource to select. Use column `RESID` of the metadata table to do this. For example:

```
SELECT COUNT(*) FROM RESOURCE_VIEW rs, imgcatmetadatatable ct
  WHERE
    XMLExists(
      'declare namespace r
         = "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
       declare namespace c
         = "cnamespace"; (: :)
       /r:Resource/c:ImgCatMetadata/Categories/Category'
      PASSING RES)
    AND rs.RESID = ct.RESID;

  COUNT(*)
----------
         1

1 row selected.
```

Oracle recommends querying for user-defined metadata directly, for performance reasons. Direct queries of the `RESOURCE_VIEW` alone *cannot be optimized* using XPath rewrite, because there is no way to determine whether or not target elements like `Category` are stored in the `CLOB` value or in an out-of-line table.

To improve performance further, create an index on each metadata column you intend to query.

Example 29–8 queries both kinds of photo resource metadata, retrieving the paths to the resources that are categorized as vacation photos and have the title "Pig Riding Horse".

Example 29–8 Query XML Schema-Based Resource Metadata

```
SELECT ANY_PATH
  FROM RESOURCE_VIEW rs, imgcatmetadatatable ct, imgtechmetadatatable tt
  WHERE XMLExists(
          'declare namespace r
             = "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
           declare namespace c
             = "cnamespace"; (: :)
           /r:Resource/c:ImgCatMetadata/Categories/Category[text()="Vacation"]'
          PASSING RES)
    AND XMLExists(
          'declare namespace r
             = "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
           declare namespace i
             = "inamespace"; (: :)
           /r:Resource/i:ImgTechMetadata/Title[text()="Pig Riding Horse"]'
          PASSING RES)
    AND rs.RESID = ct.RESID
    AND rs.RESID = tt.RESID;

ANY_PATH
-------------------------
/public/horse_with_pig.jpg

1 row selected.
```

XML Image Metadata from Binary Image Metadata

Previous sections of this chapter use a simple user-defined XML schema that defines technical image metadata, `imagetechnique.xsd`, to illustrate ways of adding and changing repository resource metadata. That simple XML schema is not intended to be realistic with respect to technical photographic image information.

However, most digital cameras include image metadata as part of the binary image files they produce, and Oracle Multimedia, which is part of Oracle Database, provides tools for extracting and converting this binary metadata to XML. Oracle Multimedia XML schemas are automatically registered with Oracle XML DB Repository to convert binary image metadata of the followings kinds to XML data:

- EXIF – Exchangeable Image File Format
- IPTC-NAA IIM – International Press Telecommunications Council-Newspaper Association of America Information Interchange Model
- XMP – Extensible Metadata Platform

EXIF is the metadata standard for digital still cameras. EXIF metadata is stored in TIFF and JPEG image files. IPTC and XMP metadata is commonly embedded in image files by desktop image-processing software.

See Also:

- *Oracle Multimedia User's Guide* for information about working with digital image metadata, including examples of extracting binary image metadata and converting it to XML
- *Oracle Multimedia Reference* for information about the XML schemas supported by Oracle Multimedia for use with image metadata

Adding Non-Schema-Based Resource Metadata

You store user-defined resource metadata that is *not* schema-based as a CLOB instance under the Resource element of the associated resource. The default XML schema for a resource has a top-level element **any** (declared with maxOccurs= "unbounded"), which admits any valid XML data as part of the resource document in the resource table, XDB.XDB$RESOURCE.

The following skeleton shows the structure and position of non-schema-based resource metadata:

```
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd"
  <Owner>DESELBY</Owner>
  ... <!-- other system-defined metadata -->
  <!-- contents of the resource>
  <Contents>
    ...
  </Contents>
  <!-- User-defined metadata (appearing within different namespace) -->
  <MyOwnMetadata xmlns="http://www.example.com/custommetadata">
    <MyElement1>value1</MyElement1>
    <MyElement2>value2</MyElement2>
  </MyOwnMetadata>
</Resource>
```

You can set and access non-schema-based resource metadata belonging to namespaces other than XDBResource.xsd by using any of the means described previously for accessing XML schema-based resource metadata.

Example 29–9 illustrates this for the case of SQL DML operations, adding user-defined metadata directly to the <RESOURCE> *document*. It shows how to add non-schema-based metadata to a resource using SQL DML.

Example 29–9 Add Non-Schema-Based Metadata to a Resource

```
DECLARE
  res BOOLEAN;
BEGIN
  res := DBMS_XDB_REPOS.createResource(
           '/public/NurseryRhyme.txt',
           bfilename('MYDIR',
                     'tdadxdb-xdb_repos_meta-011.txt'),
           nls_charset_id('AL32UTF8'));
UPDATE RESOURCE_VIEW
  SET RES = insertChildXML(RES,
                           '/r:Resource',
                           'n:NurseryMetadata',
                           XMLType('<n:NurseryMetadata xmlns:n="nurserynamespace">
                                      <Author>Mother Goose</Author>
                                    <n:NurseryMetadata>'),
                           'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                            xmlns:n="nurserynamespace"')
  WHERE equals_path(RES, '/public/NurseryRhyme.txt') = 1;
END;
/

PL/SQL procedure successfully completed.


SELECT XMLSerialize(DOCUMENT rs.RES AS CLOB) FROM RESOURCE_VIEW rs
  WHERE equals_path(RES, '/public/NurseryRhyme.txt') = 1;
```

```
XMLSERIALIZE(DOCUMENTRS.RESASCLOB)
--------------------------------------------------------------------------------
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd" Hidden="false" Inv
alid="false" Container="false" CustomRslv="false" VersionHistory="false" StickyR
ef="true">
  <CreationDate>2005-05-24T13:51:48.043234</CreationDate>
  <ModificationDate>2005-05-24T13:51:48.290144</ModificationDate>
  <DisplayName>NurseryRhyme.txt</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>text/plain</ContentType>
  <RefCount>1</RefCount>
  <ACL>
    <acl description="Public:All privileges to PUBLIC" xmlns="http://xmlns.oracl
e.com/xdb/acl.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:sch
emaLocation="http://xmlns.oracle.com/xdb/acl.xsd                          http:
//xmlns.oracle.com/xdb/acl.xsd" shared="true">
      <ace>
        <principal>PUBLIC</principal>
        <grant>true</grant>
        <privilege>
          <all/>
        </privilege>
      </ace>
    </acl>
  </ACL>
  <Owner>TDADXDB_META</Owner>
  <Creator>TDADXDB_META</Creator>
  <LastModifier>TDADXDB_META</LastModifier>
  <SchemaElement>http://xmlns.oracle.com/xdb/XDBSchema.xsd#text</SchemaElement>
  <Contents>
    <text>Mary had a little lamb
Its fleece was white as snow
and everywhere that Mary went
that lamb was sure to go
</text>
  </Contents>
  <n:NurseryMetadata xmlns:n="nurserynamespace">
    <Author xmlns="">Mother Goose</Author>
  </n:NurseryMetadata>
</Resource>

1 row selected.
```

PL/SQL Procedures Affecting Resource Metadata

The following PL/SQL procedures perform resource metadata operations:

- `DBMS_XMLSCHEMA.registerSchema` – Register an XML schema. Parameter `ENABLEHIERARCHY` affects resource metadata.
- `DBMS_XDBZ.enable_hierarchy` – Enable repository support for an `XMLType` table or view. Use parameter `HIERARCHY_TYPE` with a value of `DBMS_XDBZ.ENABLE_HIERARCHY_RESMETADATA` to enable resource metadata. This adds column `RESID` to track the resource associated with the metadata.
- `DBMS_XDBZ.disable_hierarchy` – Disable all repository support for an `XMLType` table or view.

- `DBMS_XDBZ.is_hierarchy_enabled` – Tests, using parameter `HIERARCHY_TYPE`, whether the specified type of hierarchy is currently enabled for the specified `XMLType` table or view. Value `DBMS_XDBZ.IS_ENABLED_RESMETADATA` for `HIERARCHY_TYPE` tests whether resource metadata is enabled.
- `DBMS_XDB_REPOS.appendResourceMetadata` – Add metadata to a resource.
- `DBMS_XDB_REPOS.deleteResourceMetadata` – Delete specified metadata from a resource.
- `DBMS_XDB_REPOS.purgeResourceMetadata` – Delete all user-defined metadata from a resource. For schema-based resources, optional parameter `DELETE_OPTION` can be used to specify whether or not to delete the metadata information, in addition to unlinking it.
- `DBMS_XDB_REPOS.updateResourceMetadata` – Update the metadata for a resource.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for detailed information about these PL/SQL procedures

30

Oracle XML DB Repository Events

This chapter describes repository events and how to use them. It contains these topics:

Overview of Repository Events

You can use Oracle XML DB Repository to store and access data of any kind in the form of repository resources: files and folders. Repository resource operations include creating, deleting, locking, unlocking, rendering, linking, unlinking, placing under version control, checking in, checking out, unchecking out (reverting a checked out version), opening, and updating. You can access data in the repository from any application. Sometimes your application needs to perform certain actions whenever a particular repository operation occurs. For example, you might want to perform some move-to-wastebasket or other backup action whenever a resource is deleted.

Repository Events: Use Cases

The following are examples of cases where repository events can be used:

- *Wastebasket* – You can use an `UnLink` pre-event handler to effectively move a resource to a wastebasket instead of deleting it. Create a link in a wastebasket folder before removing the original link. The link in the wastebasket ensures that the resource is not removed. When you subsequently undelete a resource from the waste basket, the original link can be created again and the wastebasket link removed. The wastebasket link name can be different from the name of the link being removed because a resource at a certain path could be unlinked more than once from that path. The wastebasket would then have multiple links corresponding to that path, with different link properties and possibly pointing to different resources.
- *Categorization* – An application might categorize the resources it manages based on MIME type or other properties. It might keep track of GIF, text, and XML files by maintaining links to them from repository folders `/my-app/gif`, `/my-app/txt`, and `/my-app/xml`. Three post-event handlers could be used here: `LinkIn`, `UnlinkIn`, and `Update`. The `LinkIn` post-event handler would examine the resource and create a link in the appropriate category folder, if not already present. The `UnlinkIn` post-event handler would remove the link from the category folder. The

`Update` post-event handler would effectively move the resource from one category folder to another if its category changes.

Repository Events and Database Triggers

Repository events are reminiscent of database triggers, but they offer additional functionality. You cannot use a database trigger to let your application react to repository operations. A given repository operation can consist of multiple database operations on multiple underlying, internal tables. Because these underlying tables are internal to Oracle XML DB, you cannot easily map them to specific repository operations. For example, internal table `XDB$H_INDEX` might be updated by either a database update operation, if an ACL is changed, or a link operation. Even in cases where you might be able to accomplish the same thing using database triggers, you would not want to do that: A repository event is a higher-level abstraction than would be a set of database triggers on the underlying tables.

When a repository event occurs, information associated with the operation, such as the resource path used, can be passed to the corresponding event handler. Such information is not readily available using database triggers.

Repository events and database triggers can both be applied to XML data. You can use triggers on `XMLType` tables, for instance. However, if an `XMLType` table is also a repository table (hierarchy-enabled), then do not duplicate in an event handler any trigger code that applies to the table. Otherwise, that code is executed twice.

Repository Event Listeners and Event Handlers

Each repository operation is associated with one or more repository events. Your application can configure listeners for the events associated with resources it is concerned with. A repository **event listener** is a Java class or a PL/SQL package or object type. It comprises a set of PL/SQL procedures or Java methods, each of which is called an **event handler**. Each event handler processes a single event. A repository event listener can be configured for a particular resource or for the entire repository. A listener can be further restricted to apply only when a given node-existence precondition is met.

You associate a repository event listener with a resource by mapping a **resource configuration file** to the resource. You use PL/SQL package `DBMS_RESCONFIG` to manipulate resource configuration files, including associating them with the resources they configure. In particular, PL/SQL function `DBMS_RESCONFIG.getListeners` lists all event listeners for a given resource.

Repository Event Configuration

A given resource can be configured by multiple resource configuration files. These are stored in a **resource configuration list**, and they are processed in list order. The repository as a whole can also be configured by multiple resource configuration files. The repository itself has a resource configuration list. Event handling that is configured for the repository as a whole takes effect before any resource-specific event handling. All applicable repository-wide events are processed before any resource-specific events.

A given resource configuration file can define multiple event listeners for the resources it configures, and each event listener can define multiple event handlers.

See Also:

- "Configuration of Repository Events" on page 30-8
- "Resource Configuration Files Configure a Resource" on page 22-1 for general information about resource configuration and resource configuration lists

Possible Repository Events

A rendering operation is associated with a single repository event. Except for rendering, all repository operations are associated with one or more *pairs* of events. For example, a resource creation is associated with three pairs of events, with the events occurring in this order:

1. Pre-creation event
2. Post-creation event
3. Pre-link-in event
4. Pre-link-to event
5. Post-link-to event
6. Post-link-in event

Table 30–1 lists the events associated with each repository operation. Their order is indicated in the handler columns.

Table 30–1 Predefined Repository Events

Repository Event Type	Description	Pre Handler Execution	Post Handler Execution
`Render`	A `Render` event occurs only for *file* resources, never for folder resources. Occurs when resource contents are accessed using any of the following: ▪ Protocols ▪ `XDBURIType` methods `getCLOB()`, `getBLOB()`, and `getXML()` Does *not* occur when resource contents are accessed using any of the following: ▪ `SELECT ... FROM RESOURCE_VIEW` ▪ `XDBURIType` method `getResource()` Only one handler for a `Render` event can set the rendered output. The first handler to call `setRenderStream` or `setRenderPath` controls the rendering.	N/A	N/A
`Create`	Occurs when a resource is created. The pre and post handlers executed are those defined on the folder of the new resource.	After pre-parsing, after validating the parent resource ACL and locks, and before assigning default values to undefined properties.	After inserting the resource into the system resource table.
`Delete`	Occurs when the resource and its contents are removed from disk, that is, when the resource `REF` count is zero (0).	After validating the resource ACL and locks and before removing the resource from disk.	After removing the resource and its contents from disk and after touching the parent folder to update its last modifier and modification time.

Table 30–1 (Cont.) Predefined Repository Events

Repository Event Type	Description	Pre Handler Execution	Post Handler Execution
`Update`	Occurs when a resource is updated on disk.	After validating the resource ACL and locks and before updating the last modifier and modification time.	After writing the resource to disk.
`Lock`	Occurs during a lock-resource operation.	After validating the resource ACL and locks and before creating the new lock on the resource.	After creating the new lock.
`Unlock`	Occurs during an unlock-resource operation.	After validating the resource ACL and delete token.	After removing the lock.
`LinkIn`	Occurs before a `LinkTo` event during a link operation. The event target is the folder in which the link is created. Always accompanied by a `LinkTo` event.	After validating the resource ACL and locks and before creating the link.	After executing `LinkTo` post handler.
`LinkTo`	Occurs after a `LinkIn` event during a link operation. The event target is the resource that is the link destination.	After executing `LinkIn` pre handler and before creating the link.	After creating the link and after updating the last modifier and modification time of the parent folder.
`UnLinkIn`	Occurs before an `UnlinkFrom` event during an unlink operation. Always accompanied by an `UnlinkFrom` event.	After validating the resource ACL and locks and before removing the link.	After executing the `UnlinkFrom` post handler.
`UnlinkFrom`	Occurs after an `UnlinkIn` event during an unlink operation.	After executing the `UnlinkIn` pre handler.	After removing the link.
`CheckIn`	Occurs during check-in of a resource.	After validating the resource ACL and locks and after verifying that the resource is version-controlled and has been checked out.	After checking in the resource.
`CheckOut`	Occurs during check-out of a resource.	After validating the resource ACL and locks and after verifying that the resource is version-controlled and is not already checked out.	After checking out the resource.
`UncheckOut`	Occurs during uncheck-out of a resource.	Before removing the record that the resource is checked out.	After unchecking out the resource.
`VersionControl`	Occurs when a version history is created for a resource. Note: You can call `DBMS_XDB_VERSION.MakeVersioned()` multiple times, but the version history is created only at the first call. Subsequent calls have no effect, so no `VersionControl` event occurs.	Before creating the version history for the resource.	After creating the first version of the resource.

For simplicity, the presentation in this chapter generally treats both members of a repository event pair together, referring, for example, to the `LinkIn` event type as shorthand for the pre-link-in and post-link-in event types. For the same reason, the event-type names used here are derived from the Java interface `XDBRepositoryEventListener` by dropping the prefixes `handlePre` and `handlePost`.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for the PL/SQL repository event types

Repository Operations and Events

The same repository event can occur with different Oracle XML DB Repository operations, and a given repository operation can produce more than one repository event. Table 30–2 lists the events that are associated with each repository operation. See Table 30–1 for the event order when multiple repository events occur for the same operations.

Table 30–2 Oracle XML DB Repository Operations and Events

Operation	Repository Events Occurring
Get binary representation of resource contents by path name	`Render`
Get XML representation of resource contents by path name	`Render`
Create or update a resource	If the resource already exists: `Create`, `LinkIn`, `LinkTo` If resource doe not yet exist (HTTP and FTP only): `Update`
Create a folder	`Create`, `LinkIn`, `LinkTo`
Create a link to an existing resource	`LinkIn` on the folder containing the link target, `LinkTo` on the target resource to be linked
Unlink a file resource or an empty folder resource. (Decrement `RefCount`, and if it becomes zero then delete the resource from disk.)	`UnlinkIn`, `UnlinkFrom`, and, if `RefCount` is zero, `Delete`
Forcibly delete a folder and its contents	Recursively produce events for unlinking a resource. Folder child resources are deleted recursively, then the folder is deleted.
Forcibly remove all links to a resource	Produce unlinking events for each link removed.
Update the contents, properties, or ACL of a resource by path name	`Update`
Put a depth-zero WebDAV lock on a resource	`Lock`
Remove a depth-zero WebDAV lock from a resource	`Lock`
Rename (move) a resource	`LinkIn` and `LinkTo` on the new location, `UnlinkIn` and `UnlinkFrom` on the old location
Copy a resource	`Create`, `LinkIn`, and `LinkTo` on the new location
Check out a resource	`CheckOut`
Check in a resource	`CheckIn`
Place a resource under version control	`VersionControl`
Uncheck out a resource	`UncheckOut`

All operations listed in Table 30–2 are atomic, except for these:

- Forced deletion of a folder and its contents
- Update of resource properties by path name using HTTP (only)
- Copy of a folder using HTTP (only)

> **See Also:** Table 21–3, " Accessing Oracle XML DB Repository: API Options" on page 21-19 for information on accessing resources using APIs and protocols

Repository Event Handler Considerations

This section mentions some things to keep in mind when you define handlers for Oracle XML DB Repository events.

- In any handler: Do not use `COMMIT`, `ROLLBACK`, or data definition language (DDL) statements in a handler. Do not call PL/SQL functions or procedures, such as `DBMS_XMLSCHEMA.registerSchema`, that behave similarly to DDL statements. In a `Render` handler: Do not use data manipulation language (DML) statements.

  To work around these restrictions, a handler can use such statements inside an autonomous transaction, but it must ensure that lock conflicts cannot arise.
- In a `Render` handler, do not close an output stream. (You can append to a stream.)
- Do *not* use modifier methods from class `XDBResource` in a handler, unless it is a `Pre-Create` or `Pre-Update` handler. Do *not* use method `XDBResource.save()` in any handler.
- Oracle recommends that you develop only safe repository event handlers. In particular:
  - Write only resource properties that are in namespaces owned by your application, never in the `xdb` namespace.
  - Do not delete a resource while it is being created.
- A repository event handler is passed an `XDBRepositoryEvent` object, which exists only during the current SQL statement or protocol operation. You can use PL/SQL procedures and Java methods on this object to obtain information about the resource, the event, and the associated event handlers.
- When an event handler performs operations that cause other repository events to occur, those cascading events occur immediately. They are not queued to occur after the handlers for the current event are finished. Each event thus occurs in the context of its corresponding operation.
- Repository event handlers are called synchronously. They are executed in the process, session, and transaction context of the corresponding operation. However, handlers can use Oracle Streams Advanced Queuing (AQ) to queue repository events that are then handled asynchronously by some other process.
- Because a repository event handler is executed in the transaction context of its corresponding operation, any locks acquired by that operation, or by other operations run previously in the transaction, are still active. An event handler must not start a separate session or transaction that tries to acquire such a lock. Otherwise, the handler hangs.
- Repository event handlers are called in the order that they appear in a resource configuration file. If preconditions are defined for a resource configuration, then only those handlers are called for which the precondition is satisfied.
- Although handlers are called in the order they are defined in a configuration file, avoid letting your code depend upon this. If the user who is current when a handler is invoked has privilege `write-config`, then the handler invocation order could be changed inside an executing handler.
- The entire list of handlers applicable to a given repository event occurrence is determined before any of the handlers is invoked. This means, in particular, that the precondition for each handler is evaluated before any handlers are invoked.
- The following considerations apply to *error handling* for repository events:

  - A pre-operation event handler is never invoked if access checks for the operation fail.
  - All handlers for a given event are checked before any of them are called. If any of them is not usable (for example, no longer exists), then *none* of them are called.
  - If an error is raised during event handling, then other, subsequent event handlers are not invoked for the same SQL statement or protocol operation. The current statement or operation is canceled and all of its changes are rolled back.

- The following considerations apply to *resource security* for repository events:
  - An event handler can have invoker's rights or definer rights. You specify the execution rights of a PL/SQL package when you create the package. You specify the execution rights of Java classes when you load them into the database using the `loadjava` utility. If you specify invoker's rights, but a given handler is not configured for invoker's rights, then an insufficient-privilege error is raised.
  - Within an event handler, the current user privileges, whether obtained by invoker or definer rights, are determined in detail for a given resource by its ACL. These privileges determine what the handler can do with the resource. For example, if the current user has privileges `read-properties` and `read-contents` for a particular resource, then an event handler can read that resource.
- The following considerations apply to repository events for *linking* and *unlinking*:
  - After creating a link to a resource, if you want any resource configuration files of the parent folder to also apply to the linked resource, then use procedure `DBMS_RESCONFIG.appendResConfig` to add the configuration files to the linked resource. You can invoke this procedure from a `Post-LinkTo` event handler for the linked resource.
  - After unlinking a resource, if you want to remove any such resource configuration files added when linking, then use procedure `DBMS_RESCONFIG.deleteResConfig` to remove them from the unlinked resource. You can invoke this procedure from a `Post-UnlinkFrom` event handler for the unlinked resource.
- Do not define handlers for events on folder `/sys/schemas` or on resources under this folder. Events do not occur for any such resources, so such event handlers are ignored. This implies that XML schema operations that affect the repository (registration, deletion, and so on) do not produce events.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL functions and procedures for manipulating repository events
- *Oracle Database XML Java API Reference*, classes `XDBRepositoryEvent` and `XDBEvent` for information about Java methods for manipulating repository events
- "Configuration of Repository Events" on page 30-8 for information about defining repository event handlers with invoker's rights

Configuration of Repository Events

You configure event treatment for Oracle XML DB Repository resources as you would configure any other treatment of repository resources—see "Configuring a Resource" on page 22-2.

By default, repository events are enabled, but you can disable them by setting parameter `XML_DB_EVENTS` to `DISABLE`. To disable repository events at the session level, use the following SQL*Plus command. You must have role `XDBADMIN` to do this.

```
ALTER SESSION SET XML_DB_EVENTS = DISABLE;
```

To disable repository events at the system level, use the following SQL*Plus command, and then restart your database. Repository events are disabled for subsequent sessions. You must have privilege `ALTER SYSTEM` to do this.

```
ALTER SYSTEM SET XML_DB_EVENTS = DISABLE;
```

To enable repository events again, set the value of `XML_DB_EVENTS` to `ENABLE`.

The rest of this section describes the resource configuration file that you use as a resource to configure event processing for other resources.

A resource configuration file is an XML file that conforms to the XML schema `XDBResConfig.xsd`, which is accessible in Oracle XML DB Repository at path `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResConfig.xsd`. You use element `event-listeners`, child of element `ResConfig`, to configure repository event handling.

> **See Also:** Chapter 22, "How to Configure Oracle XML DB Repository" for general information about configuring repository resources

Configuration Element event-listeners

Each resource configuration file can have one `event-listeners` element, as a child of element `ResConfig`. This configures all event handling for the target resource. If the resource configuration file applies to the entire repository, not to a particular resource, then it defines event handling for all resources in the repository.

Element `event-listeners` has the following optional attributes:

- `set-invoker` – Set this to `true` to if the resource configuration defines one or more repository event handlers to have invoker's rights. The default value is `false`, meaning that definer rights are used.

  To define an invoker-rights repository event handler, you must have database role `XDB_SET_INVOKER`. This role is granted to `DBA`, but not to `XDBADMIN`. Role `XDB_SET_INVOKER` is checked only when a resource configuration file is created or updated. Only attribute `set-invoker`, not role `XDB_SET_INVOKER`, is checked at run time to ensure sufficient privilege.

  > **See Also:** "Repository Event Handler Considerations" on page 30-6 for information about insufficient-privilege errors

- `default-schema` – The default schema value, used for listeners for which no `schema` element is defined.
- `default-language` –The default language value, used for listeners for which no `language` element is defined.

Element event-listeners has a sequence of listener elements as children. These configure individual repository event listeners. The listeners are processed at run time in the order of the listener elements.

Configuration Element listener

Each listener element has the following child elements. All of these are optional except source, and they can appear in any order (their order is irrelevant).

- description – Description of the listener.
- schema – Database schema for the Java or PL/SQL implementation of the repository event handlers. If neither this nor default-schema is defined, then an error is raised.
- source (required) – Name of the Java class, PL/SQL package, or object type that provides the handler methods. Java class names must be qualified with a package name. Use an empty source element to indicate that the repository event handlers are standalone PL/SQL stored procedures.
- language – Implementation language of the listener class (Java) or package (PL/SQL). If neither this nor default-language is defined, then an error is raised.
- pre-condition – Precondition to be met for any repository event handlers in this listener to be executed. This is identical to the pre-condition child of general resource configuration element configuration – see "Configuration Element defaultChildConfig" on page 22-4.
- events – Sequence of unique repository event type names: Render, Pre-Create, and so on. Only handlers for repository events of these types are enabled for the listener. See "Possible Repository Events" on page 30-3 for the list of possible repository event types. If element events is not present, then handlers of repository events of all types are enabled for the listener, which can be wasteful. Provide element events to eliminate handler invocations for insignificant repository events.

Repository Events Configuration Examples

Example 30–1 shows the content of a resource configuration file that defines two listeners. Each listener defines handlers for repository events of types Post-LinkIn, Post-UnlinkIn, and Post-Update. It defines preconditions, the default language (Java) and default database schema.

Example 30–1 Resource Configuration File for Java Event Listeners with Preconditions

```
<ResConfig xmlns="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
           xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
           xsi:schemaLocation="http://xmlns.oracle.com/xdb/XDBResConfig.xsd
                               http://xmlns.oracle.com/xdb/XDBResConfig.xsd">
  <event-listeners default-language="Java" default-schema="IFS">
    <listener>
      <description>Category application</description>
      <schema>CM</schema>
      <source>oracle.cm.category</source>
      <events>
        <Post-LinkIn/>
        <Post-UnlinkIn/>
        <Post-Update/>
      </events>
      <pre-condition>
```

```
        <existsNode>
          <XPath>/Resource[ContentType="image/gif"]</XPath>
        </existsNode>
      </pre-condition>
    </listener>
    <listener>
      <description>Check quota</description>
      <source>oracle.ifs.quota</source>
      <events>
        <Post-LinkIn/>
        <Post-UnlinkIn/>
        <Post-Update/>
      </events>
      <pre-condition>
        <existsNode>
          <XPath>r:/Resource/[ns:type="ifs-file"]</XPath>
          <namespace>xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                     xmlns:ns="http://foo.xsd"
          </namespace>
        </existsNode>
      </pre-condition>
    </listener>
  </event-listeners>
  <defaultChildConfig>
    <configuration>
      <path>/sys/xdb/resconfig/user_rc.xml</path>
    </configuration>
  </defaultChildConfig>
  <applicationData>
    <foo:data xmlns:foo="http://foo.xsd">
      <foo:item1>1234</foo:item1>
    </foo:data>
  </applicationData>
</ResConfig>
```

The implementation of the handlers of the first listener is in Java class `oracle.cm.quota` defined in database schema `CM`. These handlers are invoked only for events on resources of `ContentType image/gif`.

The implementation of the handlers of the second listener is in Java class `oracle.ifs.quota` defined in database schema `IFS` (the default schema for this resource configuration file). These handlers are invoked only for events on resources of type `ifs-file` in namespace `http://foo.xsd`.

> **See Also:** "Configuration Element defaultChildConfig" on page 22-4 for a description of elements `defaultChildConfig` and `applicationData`

As a simple end-to-end illustration, suppose that an application needs to categorize the resources in folder `/public/res-app` according to their MIME types. It creates links to resources in folders `/public/app/XML-TXT`, `/public/app/IMG`, and `/public/app/FOLDER`, depending on whether the resource MIME type is `text/xml`, `image/gif`, or `application/octet-stream`, respectively. This is illustrated in Example 30–2, Example 30–3, and Example 30–5.

Example 30–2 shows the PL/SQL code to create the configuration file for this categorization illustration. It defines a single listener that handles events of types `Pre-UnlinkIn` and `Post-LinkIn`. It explicitly defines the language (PL/SQL) and database schema. No preconditions are defined.

Example 30–2 Resource Configuration File for PL/SQL Event Listeners with No Preconditions

```
DECLARE
  b BOOLEAN := FALSE;
BEGIN
  b := DBMS_XDB_REPOS.createFolder('/public/resconfig');
  b := DBMS_XDB_REPOS.createResource(
         '/public/resconfig/appcatg-rc1.xml',
         '<ResConfig xmlns="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
                     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                     xsi:schemaLocation="http://xmlns.oracle.com/xdb/XDBResConfig.xsd
                                         http://xmlns.oracle.com/xdb/XDBResConfig.xsd">
            <event-listeners>
              <listener>
                <description>Category application</description>
                <schema>APPCATGUSER1</schema>
                <source>APPCATG_EVT_PKG1</source>
                <language>PL/SQL</language>
                <events>
                  <Pre-UnlinkIn/>
                  <Post-LinkIn/>
                </events>
              </listener>
            </event-listeners>
            <defaultChildConfig>
              <configuration>
                <path>/public/resconfig/appcatg-rc1.xml</path>
              </configuration>
            </defaultChildConfig>
          </ResConfig>',
         'http://xmlns.oracle.com/xdb/XDBResConfig.xsd',
         'ResConfig');
END;
/
BEGIN
  DBMS_RESCONFIG.appendResConfig('/public/res-app',
                                 '/public/resconfig/appcatg-rc1.xml',
                                 DBMS_RESCONFIG.APPEND_RECURSIVE);
END;
/
```

Example 30–3 shows the PL/SQL code that implements the event handlers that are configured in Example 30–2. The `Post-LinkIn` event handler creates a link to the `eventObject` resource in one of the folders `/public/app/XML-TXT`, `/public/app/IMG`, and `/public/app/FOLDER`, depending on the resource MIME type. The `Pre-UnlinkIn` event handler deletes the links that are created by the `Post-LinkIn` event handler.

Example 30–3 PL/SQL Code Implementing Event Listeners

```
CREATE OR REPLACE PACKAGE appcatg_evt_pkg1 AS

  PROCEDURE handlePreUnlinkIn (eventObject DBMS_XEVENT.XDBRepositoryEvent);
  PROCEDURE handlePostLinkIn (eventObject DBMS_XEVENT.XDBRepositoryEvent);

END;
/
CREATE OR REPLACE PACKAGE BODY appcatg_evt_pkg1 AS

  PROCEDURE handlePreUnlinkIn (eventObject DBMS_XEVENT.XDBRepositoryEvent) AS
      XDBResourceObj DBMS_XDBRESOURCE.XDBResource;
      ResDisplayName VARCHAR2(100);
```

```
    ResPath        VARCHAR2(1000);
    ResOwner       VARCHAR2(1000);
    ResDeletedBy   VARCHAR2(1000);
    XDBPathobj     DBMS_XEVENT.XDBPath;
    XDBEventobj    DBMS_XEVENT.XDBEvent;
    SeqChar        VARCHAR2(1000);
    LinkName       VARCHAR2(10000);
    ResType        VARCHAR2(100);
    LinkFolder     VARCHAR2(100);
  BEGIN
    XDBResourceObj := DBMS_XEVENT.getResource(eventObject);
    ResDisplayName := DBMS_XDBRESOURCE.getDisplayName(XDBResourceObj);
    ResOwner       := DBMS_XDBRESOURCE.getOwner(XDBResourceObj);
    XDBPathobj     := DBMS_XEVENT.getPath(eventObject);
    ResPath        := DBMS_XEVENT.getName(XDBPathObj);
    XDBEventobj    := DBMS_XEVENT.getXDBEvent(eventObject);
    ResDeletedBy   := DBMS_XEVENT.getCurrentUser(XDBEventobj);
    BEGIN
      SELECT XMLCast(
               XMLQuery(
                 'declare namespace ns = "http://xmlns.oracle.com/xdb/XDBResource.xsd";
                  /ns:Resource/ns:ContentType'
                 PASSING r.RES RETURNING CONTENT) AS VARCHAR2(100))
        INTO ResType
        FROM PATH_VIEW r WHERE r.PATH=ResPath;
        EXCEPTION WHEN OTHERS THEN NULL;
    END;
    IF ResType = 'text/xml' THEN LinkFolder := '/public/app/XML-TXT/';
    END IF;
    IF ResType = 'image/gif' THEN LinkFolder := '/public/app/IMG/';
    END IF;
    IF ResType = 'application/octet-stream' THEN LinkFolder := '/public/app/FOLDER/';
    END IF;
    DBMS_XDB_REPOS.deleteResource(LinkFolder || ResDisplayName);
END;

PROCEDURE handlePostLinkIn (eventObject DBMS_XEVENT.XDBRepositoryEvent) AS
    XDBResourceObj DBMS_XDBRESOURCE.XDBResource;
    ResDisplayName VARCHAR2(100);
    ResPath        VARCHAR2(1000);
    ResOwner       VARCHAR2(1000);
    ResDeletedBy   VARCHAR2(1000);
    XDBPathobj     DBMS_XEVENT.XDBPath;
    XDBEventobj    DBMS_XEVENT.XDBEvent;
    SeqChar        VARCHAR2(1000);
    LinkName       VARCHAR2(10000);
    ResType        VARCHAR2(100);
    LinkFolder     VARCHAR2(100);
  BEGIN
    XDBResourceObj := DBMS_XEVENT.getResource(eventObject);
    ResDisplayName := DBMS_XDBRESOURCE.getDisplayName(XDBResourceObj);
    ResOwner       := DBMS_XDBRESOURCE.getOwner(XDBResourceObj);
    XDBPathobj     := DBMS_XEVENT.getPath(eventObject);
    ResPath        := DBMS_XEVENT.getName(XDBPathObj);
    XDBEventobj    := DBMS_XEVENT.getXDBEvent(eventObject);
    ResDeletedBy   := DBMS_XEVENT.getCurrentUser(XDBEventobj);
    SELECT XMLCast(
             XMLQuery(
               'declare namespace ns = "http://xmlns.oracle.com/xdb/XDBResource.xsd";
                /ns:Resource/ns:ContentType'
```

```
              PASSING r.RES RETURNING CONTENT) AS VARCHAR2(100))
       INTO ResType
       FROM PATH_VIEW r WHERE r.PATH=ResPath;
     IF ResType = 'text/xml' THEN LinkFolder := '/public/app/XML-TXT';
     END IF;
     IF ResType = 'image/gif' THEN LinkFolder := '/public/app/IMG';
     END IF;
     IF ResType = 'application/octet-stream' THEN LinkFolder := '/public/app/FOLDER';
     END IF;
     DBMS_XDB_REPOS.link(ResPath, LinkFolder, ResDisplayName);
   END;
END;
/
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XDBRESOURCE`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XEVENT`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XDB_REPOS`

A Java example would be configured the same as in Example 30–2, with the exception of these two lines, which would replace the elements with the same names in Example 30–2:

```
<source>category</source>
<language>Java</language>
```

Example 30–4 shows the Java code that implements the event handlers. The logic is identical to that in Example 30–3.

Example 30–4 Java Code Implementing Event Listeners

```
import oracle.xdb.event.*;
import oracle.xdb.spi.*;
import java.sql.*;
import java.io.*;
import java.net.*;
import oracle.jdbc.*;
import oracle.sql.*;
import oracle.xdb.XMLType;
import oracle.xdb.dom.*;

public class category
extends oracle.xdb.event.XDBBasicEventListener
{
  public Connection connectToDB() throws java.sql.SQLException
  {
    try
    {
      String strUrl="jdbc:oracle:kprb:";
      String strUname="appcatguser1";
      String strPwd="appcatguser1 ";
      Connection conn=null;
      OraclePreparedStatement stmt=null;
      DriverManager.registerDriver(new oracle.jdbc.OracleDriver());
```

```
    conn = DriverManager.getConnection(strUrl, strUname, strPwd);
    return conn;
  }
  catch(Exception e1)
  {
    System.out.println("Exception in connectToDB java function");
    System.out.println("e1:" + e1.toString());
    return null;
  }
}
public void handlePostLinkIn (XDBRepositoryEvent eventObject)
{
  XDBPath objXDBPath = null;
  String strPathName="";
  objXDBPath = eventObject.getPath();
  strPathName = objXDBPath.getName();
  XDBResource objXDBResource1;
  objXDBResource1 = eventObject.getResource();
  String textResDisplayName = objXDBResource1.getDisplayName();
  String resType = objXDBResource1.getContentType();
  String linkFolder="";
  System.out.println("resType" + resType+"sumit");
  System.out.println("strPathName:" + strPathName);
  System.out.println("textResDisplayName:" + textResDisplayName);
  if (resType.equals("text/xml")) linkFolder = "/public/app/XML-TXT/";
  else if (resType.equals("image/gif")) linkFolder = "/public/app/IMG/";
  else if (resType.equals("application/octet-stream"))
          linkFolder = "/public/app/FOLDER/";
  System.out.println("linkFolder:" + linkFolder);
  try
  {
    Connection con1 = connectToDB();
    OraclePreparedStatement stmt=null;
    stmt = (OraclePreparedStatement)con1.prepareStatement(
              "CALL DBMS_XDB_REPOS.link(?,?,?)");
    stmt.setString(1,strPathName);
    stmt.setString(2,linkFolder);
    stmt.setString(3,textResDisplayName);
    stmt.execute();
    stmt.close();
    con1.close();
  }
  catch(java.sql.SQLException ej1)
  {
    System.out.println("ej1:" + ej1.toString());
  }

/* Make sure the link is not in the category folders.
   Then check the target resource's mime type and create a link
   in the appropriate category folder. */
}
public void handlePreUnlinkIn (XDBRepositoryEvent eventObject)
{
  XDBPath objXDBPath = null;
  String strPathName="";
  objXDBPath = eventObject.getPath();
  strPathName = objXDBPath.getName();
  XDBResource objXDBResource1;
  objXDBResource1 = eventObject.getResource();
  String textResDisplayName = objXDBResource1.getDisplayName();
```

```
    String resType = objXDBResource1.getContentType();
    String linkFolder="";
    if (resType.equals("text/xml")) linkFolder = "/public/app/XML-TXT/";
    else if (resType.equals("image/gif")) linkFolder = "/public/app/IMG/";
    else if (resType.equals("application/octet-stream"))
            linkFolder = "/public/app/FOLDER/";
    try
    {
      Connection con1 = connectToDB();
      OraclePreparedStatement stmt=null;
      stmt = (OraclePreparedStatement)con1.prepareStatement(
               "CALL DBMS_XDB_REPOS.deleteResource(?)");
      stmt.setString(1,linkFolder+textResDisplayName);
      stmt.execute();
      stmt.close();
      con1.close();
    }
    catch(java.sql.SQLException ej1)
    {
      System.out.println("ej1:" + ej1.toString());
    }
  }
}
```

Example 30–5 demonstrates the invocation of the event handlers that are implemented in Example 30–3 or Example 30–4.

Example 30–5 Invoking Event Handlers

```
DECLARE
  ret BOOLEAN;
BEGIN
  ret := DBMS_XDB_REPOS.createResource('/public/res-app/res1.xml',
                                       '<name>TestForEventType-1</name>');
END;
/
DECLARE
  b BOOLEAN := FALSE;
  dummy_data CLOB := 'AAA';
BEGIN
  b := DBMS_XDB_REPOS.createResource('/public/res-app/res2.gif', dummy_data);
END;
/
DECLARE
  b BOOLEAN := FALSE;
  dummy_data CLOB := 'AAA';
BEGIN
  b := DBMS_XDB_REPOS.createFolder('/public/res-app/res-appfolder1');
END;

SELECT PATH FROM PATH_VIEW WHERE PATH LIKE '/public/app/%' ORDER BY PATH;

PATH
--------------------------------
/public/app/FOLDER
/public/app/FOLDER/res-appfolder1
/public/app/IMG
/public/app/IMG/res2.gif
/public/app/XML-TXT
/public/app/XML-TXT/res1.xml
```

```
6 rows selected.

-- Delete the /res-app resources. The /app resources are deleted also.
EXEC DBMS_XDB_REPOS.deleteResource('/public/res-app/res2.gif');
EXEC DBMS_XDB_REPOS.deleteResource('/public/res-app/res1.xml');
EXEC DBMS_XDB_REPOS.deleteResource('/public/res-app/res-appfolder1');

SELECT PATH FROM PATH_VIEW WHERE PATH LIKE '/public/app/%' ORDER BY PATH;

PATH
-------------------
/public/app/FOLDER
/public/app/IMG
/public/app/XML-TXT

3 rows selected.
```

31

Oracle XML DB Content Connector

This chapter describes how to use Oracle XML DB Content Connector to access Oracle XML DB Repository.

Oracle XML DB Content Connector implements Content Repository API for Java (also known as JCR), a Java API standard developed by the Java community as JSR-170.

This chapter contains these topics:

Overview of JCR and Oracle XML DB Content Connector

This section contains the following topics:

About the Content Repository API for Java (JCR)

JCR 1.0 defines a standard Java API for applications to interact with content repositories.

> **See Also:** Java Community Process, "Content Repository for Java technology API", `http://jcp.org/en/jsr/detail?id=170`. Chapter 4 of the JSR-170 specification provides a concise introduction to JCR 1.0

JCR models the data in a content repository as a tree of nodes. Each node may have one or more child nodes. Every node has exactly one parent node, except for the root node, which has no parent.

In addition to child nodes, a node may also have one or more properties. A property is a simple name/value pair. For example, a node representing a particular file in the content repository has a property named `jcr:created` whose value is the date the file was created.

Each property has a property type. For example, the `jcr:created` property has the `DATE` property type, requiring its value to be a valid date/time.

Similarly, each node has a node type. For example, a node representing a file has node type `nt:file`. The node type controls what child nodes and properties the node may

have or must have. For example, all nodes of type `nt:file` must have a `jcr:created` property.

Because nodes and properties are named, they can be addressed by path. JCR supports both absolute and relative paths. For example, the absolute path

```
/My Documents/pictures/puppy.jpg/jcr:created
```

resolves to the `jcr:created` property of file `puppy.jpg`. This property can also be addressed relative to the `My Documents` folder by the following relative path:

```
pictures/puppy.jpg/jcr:created
```

Node and property names can be namespace qualified. Like XML, JCR uses colon-delimited namespace prefixes to express namespace-qualified names, for example, `jcr:created`. Unlike XML, JCR records the namespace prefix-to-URI mappings in a repository-wide namespace registry, which, for example, maps the `jcr` prefix to the URI `http://www.jcp.org/jcr/1.0`.

About Oracle XML DB Content Connector

Oracle XML DB Content Connector lets you access Oracle XML DB Repository using the JCR 1.0 Java API. Your applications can run either in a standalone Java Virtual Machine (JVM) or a J2EE container.

> **Note:** Using Oracle XML DB Content Connector in the database Oracle JVM (the Java Virtual Machine available within a database process) is not supported. To use the content connector in the database tier, you must use either a standalone Java Virtual Machine or a J2EE container.

Files and folders in Oracle XML DB Repository are represented as JCR nodes (and properties of those nodes). They can be created, retrieved, and updated using the JCR APIs.

How Oracle XML DB Repository Is Exposed in JCR

Oracle XML DB Content Connector represents data in Oracle XML DB Repository as JCR nodes and properties. Files and folders are represented as nodes of type `nt:file` and `nt:folder`, respectively. Their content and metadata is exposed as nodes of node type `nt:resource`.

This section contains the following topics:

Example of How Files and Folders are Exposed in JCR

The folder `MyFolder` is stored in the root folder of Oracle XML DB Repository. It contains two files, `Address.xml` and `Car.jpg`.

File `Address.xml` has the following XML content:

```
<Address country="US">
  <name>Alice Smith</name>
  <street>123 Maple Street</street>
  <city>Mill Valley</city>
  <state>CA</state>
  <zip>90952</zip>
</Address>
```

File `Car.jpg` has binary content: a picture of an automobile. It also has the following user-defined XML metadata:

```
<i:ImageMetadata>
  <Height>640</Height>
  <Width>480</Width>
  <RGB R="44" G="123" B="74"/>
</i:ImageMetadata>
```

Oracle XML DB Content Connector exposes `MyFolder`, `Address.xml`, and `Car.jpg` as JCR nodes and properties.

Example 31–1 shows folder `MyFolder` represented as a tree of JCR nodes and properties. In this representation, **`bold`** type indicates a node, *`italic`* type indicates a node type, `regular` type indicates a property, and italic type with angle brackets (<>) indicates omitted data, such as binary data.

Example 31–1 JCR Node Representation of MyFolder

```
[root] (nt:folder)
  jcr:created="2001-01-01T00:00:00.000Z"
  jcr:content (nt:resource)
    jcr:data=null
    jcr:lastModified="2001-01-01T00:00:00.000Z"
    ojcr:owner="SYS"
    ojcr:creator="SYS"
    ojcr:lastModifier="SYS"
    ojcr:displayName=""
    ojcr:language="en-US"
  MyFolder (nt:folder)
    jcr:created="2001-01-01T00:00:00.000Z"
    jcr:content (nt:resource)
      jcr:data=null
      jcr:lastModified="2001-01-01T00:00:00.000Z"
      ojcr:owner="ALICE"
      ojcr:creator="BOB"
      ojcr:lastModifier="CHARLIE"
      ojcr:author="BOB"
      ojcr:comment="An application folder"
      ojcr:displayName="MyFolder"
      ojcr:language="en-US"
      ojcr:links (ojcr:links)
        ojcr:folderLink (ojcr:linkProperties)
          ojcr:linkType="Hard"
          ojcr:linkSource=<RESID of the root folder>
          ojcr:linkTarget=<RESID of folder MyFolder>
          ojcr:linkName="MyFolder"
```

```
Address.xml (nt:file)
  jcr:created="2005-09-01T12:34:56.789Z"
  jcr:content (nt:resource)
    jcr:encoding="UTF-8"
    jcr:mimeType="text/xml"
    jcr:data=<binary representation of the XML content>
    jcr:lastModified="2005-09-01T12:34:56.789Z"
    ojcr:owner="ALICE"
    ojcr:creator="BOB"
    ojcr:lastModifier="CHARLIE"
    ojcr:author="BOB"
    ojcr:displayName="Address.xml"
    ojcr:language="en-US"
    ojcr:xmlContent (nt:unstructured)
      Address
        country="US"
        name
          jcr:xmltext
            jcr:xmlcharacters="Alice Smith"
        street
          jcr:xmltext
            jcr:xmlcharacters="123 Maple Street"
        city
          jcr:xmltext
            jcr:xmlcharacters="Mill Valley"
        state
          jcr:xmltext
            jcr:xmlcharacters="CA"
        zip
          jcr:xmltext
            jcr:xmlcharacters="90952"
    ojcr:links (ojcr:links)
      ojcr:folderLink (ojcr:linkProperties)
        ojcr:linkType="Hard"
        ojcr:linkSource=<RESID of folder MyFolder>
        ojcr:linkTarget=<RESID of file Address.xml>
        ojcr:linkName="Address.xml"
Car.jpg (nt:file)
  jcr:created="2004-02-12T16:15:23.247Z"
  jcr:content (nt:resource)
    jcr:mimeType="image/jpeg"
    jcr:data=<binary content of file Car.jpg>
    jcr:lastModified="2004-02-12T17:20:25.314Z"
    ojcr:owner="ALICE"
    ojcr:creator="BOB"
    ojcr:lastModifier="CHARLIE"
    ojcr:author="BOB"
    ojcr:displayName="A shiny red car!"
    ojcr:language="en-US"
    i:ImageMetadata
      Height
        jcr:xmltext
          jcr:xmlcharacters="640"
      Width
        jcr:xmltext
          jcr:xmlcharacters="480"
      RGB
        R="44"
        G="123"
        B="74"
```

```
ojcr:links (ojcr:links)
  ojcr:folderLink (ojcr:linkProperties)
    ojcr:linkType="Hard"
    ojcr:linkSource=<RESID of folder MyFolder>
    ojcr:linkTarget=<RESID of file Car.jpg>
    ojcr:linkName="Car.jpg"
```

Oracle Extensions to JCR Node Types

Oracle XML DB Content Connector augments the definitions of node types `nt:file`, `nt:folder`, and `nt:resource` to include additional information held in Oracle XML DB Repository. Node type `ojcr:folder` is added as a supertype of `nt:folder`, and node type `ojcr:resource` is added as a supertype of `nt:resource`. All Oracle extensions are in the namespace `http://xmlns.oracle.com/jcr/1.0`, which is mapped to namespace prefix **`ojcr`**.

In addition, node type `mix:referenceable` is added as a supertype of `nt:file` and `nt:folder` to allow all files and folders to be accessed by their resource id.

Binary and XML Content

Property `jcr:data` contains the binary content of a file. Note that `jcr:data` is a property not of node `nt:file`, but rather of its child node `jcr:content`.

For files containing XML content, node `jcr:content` has a child node `ojcr:xmlContent`, under which the XML content can be accessed as a set of JCR nodes and properties. File `Address.xml`, referenced in Example 31–1 on page 31-3, is such a file. The XML content of an XML file in the repository is mapped to JCR nodes and properties using the **document view serialization** defined by JCR, in which:

- XML elements are exposed as JCR nodes.
- XML attributes are exposed as JCR properties.
- XML text is exposed as JCR properties named `jcr:xmlcharacters` within nodes named `jcr:xmltext`.

System-Defined Metadata

Oracle XML DB Repository maintains metadata for each repository file and folder. In database views `RESOURCE_VIEW` and `PATH_VIEW`, this metadata is represented as a set of XML elements within `XMLType` column `RES`. In JCR, this metadata is mapped to properties in namespaces `jcr` and `ojcr`. Table 31–1 describes this mapping.

Table 31–1 Oracle XML DB Resource to JCR Mappings

XPath	Relative Path From Node nt:file or nt:folder
`/Resource/CreationDate`	`jcr:created`
`/Resource/ModificationDate`	`jcr:content/jcr:lastModified`
`/Resource/Author`	`jcr:content/ojcr:author`
`/Resource/DisplayName`	`jcr:content/ojcr:displayName`
`/Resource/Comment`	`jcr:content/ojcr:comment`
`/Resource/Language`	`jcr:content/ojcr:language`
`/Resource/CharacterSet`	`jcr:content/jcr:encoding`
`/Resource/ContentType`	`jcr:content/jcr:mimeType`

Table 31–1 (Cont.) Oracle XML DB Resource to JCR Mappings

XPath	Relative Path From Node nt:file or nt:folder
/Resource/Owner	jcr:content/ojcr:owner
/Resource/Creator	jcr:content/ojcr:creator
/Resource/LastModifier	jcr:content/ojcr:lastModifier

User-Defined Metadata

User-defined XML metadata is exposed as JCR nodes and properties under the `jcr:content` child node of the repository file or folder. As with XML file content, XML metadata is mapped to JCR nodes and properties using the document view serialization that is defined by JCR. See "Binary and XML Content" on page 31-5 for a description of this serialization.

In Example 31–1, file `Car.jpg` has this user-defined metadata:

```
<i:ImageMetadata>
  <Height>640</Height>
  <Width>480</Width>
  <RGB R="44" G="123" B="74"/>
</i:ImageMetadata>
```

The following JCR path retrieves the `Width` value:

```
/My Folder/Car.jpg/jcr:content/i:ImageMetadata/
   Width/jcr:xmltext/jcr:xmlcharacters
```

Hard Links and Weak Links

In JCR, each node and property has exactly one parent node, except for the root node, which has no parent. Consequently, there is exactly one absolute path to each JCR node or property.

However, in Oracle XML DB Repository, a resource (file or folder) can be linked to more than one parent folder, either by hard links, which control the life span of the child, or by weak links, which do not. Consequently, there can be more than one path to a resource, and a resource can have more than one parent.

In resolving a path, Oracle XML DB Content Connector traverses both hard and weak links. If there is more than one path to a resource, JCR method `getPath()` returns the path by which that resource was first discovered, subsequent to the most recent call to either `save()` or `refresh(boolean)` by that session. JCR method `getParent()` returns the folder targeted by that path.

It is often useful to obtain a list of all parents of a resource, if the resource is the target of more than one link and therefore has more than one parent folder. Oracle XML DB Content Connector presents this as nodes of type `ojcr:linkProperties` with path `jcr:content/ojcr:links/ojcr:folderLink` relative to node `nt:file` or `nt:folder`. There is one `ojcr:folderLink` node for each parent of the resource.

Node `ojcr:folderLink` has the following properties:

- `ojcr:linkType`: Link type (`Hard` or `Weak`)
- `ojcr:linkSource`: Resource id of the parent folder
- `ojcr:linkTarget`: Resource id of the child file or folder
- `ojcr:linkName`: Name of the child file or folder in that parent

How to Use Oracle XML DB Content Connector

This section describes how to use Oracle XML DB Content Connector to access information in Oracle XML DB Repository. It has the following topics:

CLASSPATH for Oracle XML DB Content Connector

Oracle XML DB Content Connector requires the following entries in environment variable `CLASSPATH`:

- `$ORACLE_HOME/lib/jcr-1.0.jar`
- `$ORACLE_HOME/lib/ojcr.jar`
- `$ORACLE_HOME/lib/xmlparserv2.jar`
- `$ORACLE_HOME/jlib/xquery.jar`

Obtaining the JCR Repository Object

In Oracle XML DB Content Connector, `oracle.jcr.OracleRepository` implements the JCR interface `javax.jcr.Repository`, which provides the entry point to a JCR repository. The code fragment in Example 31–2 shows how to obtain a `Repository` object for Oracle XML DB Repository.

Example 31–2 Code Fragment Showing How to Get a Repository Object

```
import oracle.jcr.OracleRepository;
import oracle.jcr.OracleRepositoryFactory;
import oracle.jcr.xdb.XDBRepositoryConfiguration;
import oracle.jdbc.pool.OracleDataSource;
...
XDBRepositoryConfiguration configuration =
  new XDBRepositoryConfiguration();
OracleDataSource ods =
  (OracleDataSource)configuration.getDataSource();
// databaseURL is a JDBC database URL.
ods.setURL(databaseURL);
// OracleRepository implements javax.jcr.Repository.
OracleRepository repository =
  OracleRepositoryFactory.createOracleRepository(configuration);
```

`OracleRepository` implements both `java.io.Serializable` and `javax.naming.Referenceable`. This lets you create and configure an `OracleRepository` object upon application deployment, and store the ready-to-use `OracleRepository` object in a JNDI directory. At run-time, your application can retrieve the preconfigured `OracleRepository` object from the JNDI directory. This

approach, recommended by the JCR specification, separates deployment and run-time concerns.

In Oracle XML DB Content Connector, the set of prefix-to-URI mappings forming the JCR namespace registry is stored as part of the `OracleRepository` configuration.

> **See Also:** *Oracle Database XML Java API Reference*, package `oracle.jcr`

Java Code to Upload a File to the Repository using Oracle XML DB Content Connector

Example 31–3 is a Java program that uploads a file from the local file system to Oracle XML DB Repository using Oracle XML DB Content Connector.

Example 31–3 Uploading a File Using Oracle XML DB Content Connector

```
import java.io.FileInputStream;

import javax.jcr.Node;
import javax.jcr.Session;
import javax.jcr.SimpleCredentials;

import oracle.jcr.OracleRepository;
import oracle.jcr.OracleRepositoryFactory;

import oracle.jcr.xdb.XDBRepositoryConfiguration;

import oracle.jdbc.pool.OracleDataSource;

public class UploadFile
{
  public static void main(String[] args)
    throws Exception
  {
    String databaseURL = args[0];
    String userName = args[1];
    String password = args[2];
    String parentPath = args[3];
    String fileName = args[4];
    String mimeType = args[5];

    // Get the JCR Repository object.
    XDBRepositoryConfiguration configuration =
      new XDBRepositoryConfiguration();

    OracleDataSource ods =
      (OracleDataSource)configuration.getDataSource();

    ods.setURL(databaseURL);

    OracleRepository repository =
      OracleRepositoryFactory.createOracleRepository(configuration);

    // Create a JCR Session.
    SimpleCredentials sc =
      new SimpleCredentials(userName, password.toCharArray());

    Session session = repository.login(sc);

    // Get the parent node.
```

```
    Node parentNode = (Node)session.getItem(parentPath);

    // Get the child contents.
    FileInputStream inputStream = new FileInputStream(fileName);

    // Create child node.
    Node node = parentNode.addNode(fileName, "nt:file");
    Node contentNode = node.getNode("jcr:content");
    contentNode.setProperty("jcr:mimeType", mimeType);
    contentNode.setProperty("jcr:data", inputStream);

    // Save changes and logout.
    session.save();
    session.logout();
  }
}

// EOF
```

You can compile and run Example 31–3 from the command line. The program requires the following command-line arguments:

- JDBC database URL
- User ID
- User password
- Folder in Oracle XML DB Repository into which to upload the file
- File to be uploaded
- MIME type

Example 31–4 illustrates this.

Example 31–4 Uploading a File Using the Command Line

```
export CLASSPATH=.:$ORACLE_HOME/lib/jcr-1.0.jar:$ORACLE_HOME/lib/ojcr.jar:[1]
$ORACLE_HOME/lib/xmlparserv2.jar:$ORACLE_HOME/jlib/xquery.jar

javac UploadFile.java
java UploadFile jdbc:oracle:oci:@ quine password /public MyFile.txt text/plain
```

Additional Code Examples

You can find additional sample code at the following location:

```
$ORACLE_HOME/xdk/demo/java/jcr
```

For each code sample, a `README` file describes its purpose and use.

Use the Standard Java Logging API for Oracle XML DB Content Connector

Oracle XML DB Content Connector uses the standard `java.util.logging` framework. You can use the logging API provided by that framework to control logging behavior. For example, the following Java code fragment disables all logging.

```
import java.util.logging.LogManager;
...
```

[1] This statement is split across two lines for the purpose of documentation.

```
LogManager.getLogManager().reset();
```

Supported JCR Compliance Levels

The JSR-170 standard, which defines JCR version 1.0, defines two compliance levels and a set of optional features. Oracle XML DB Content Connector supports Level 1 (read functions) and Level 2 (write functions).

Oracle XML DB Content Connector Restrictions

This section describes certain restrictions of Oracle XML DB Content Connector.

Default Workspace Name

A single workspace is supported. In calling the `login(Credentials, String)` or `login(String)` methods of `javax.jcr.Repository`, the workspace name must be either an empty-string (`""`) or `NULL`.

Operations Restricted to Specific Node Types

Methods `save()` and `refresh()` of `javax.jcr.Item` can be called only on nodes whose type is `nt:file` or `nt:folder`. Method `move()` of `javax.jcr.Session` and methods `copy()` and `move()` of `javax.jcr.Workspace` can be called only on `nt:file` and `nt:folder` nodes.

Determining the State of Files or Folders

Methods `isNew()` and `isModified()` of `javax.jcr.Item` return the state of the file or folder containing the item, not the item itself. Method `isNew()` returns `true` if the file or folder has been created in the JCR transient layer but not saved. Method `isModified()` returns `true` if the file or folder has been changed in the transient layer but not saved.

Interaction Between Binary and XML Content

The `jcr:data` property contains the binary-format content of a file. If the file content is XML, there is also an `ojcr:xmlContent` node under which its XML content is exposed as JCR nodes and properties. Changes you make to the `ojcr:xmlContent` subtree are not reflected in the `jcr:data` property until those changes are saved. If you change both the `jcr:data` property and the `ojcr:xmlContent` subtree, then the `ojcr:xmlContent` subtree takes precedence when those changes are saved.

Order in Which Changes Are Saved

Method `save` of class `javax.jcr.Session` or class `javax.jcr.Item` saves changes made in the transient layer. If more than one node or property has been changed, then JCR does not specify the order in which the changes are stored. Oracle XML DB Content Connector saves changes in the following:

1. Apply updates to existing files and folders, in path-sorted order.
2. Create new files and folders, in path-sorted order.
3. Move existing files and folders, in reverse path-sorted order.
4. Delete existing files and folders, in reverse path-sorted order.

Undefined Properties

Properties that have definitions of type `UNDEFINED` are stored as `STRING` values.

Node Type nt:base Is Abstract

Node type `nt:base` is abstract and cannot be specified as the type of a new node.

Node jcr:content Is Created Automatically

When you create a node of type `nt:file` or `nt:folder`, a `jcr:content` node is created automatically as a child.

Saving Normalizes Node jcr:xmltext

Saving combines successive `jcr:xmltext` nodes, which represent text within XML content or user-defined metadata, into a single `jcr:xmltext` node.

Node Type mix:referenceable

Node types `nt:file`, `nt:folder`, and `nt:resource` are subtypes of mix-in node type `mix:referenceable`. Consequently, all `nt:file`, `nt:folder`, and `nt:resource` nodes can be referenced by UUID. You cannot add `mix:referenceable` to nodes of any type.

Full-Text Indexing

You can create a full-text index on file content using PL/SQL package `DBMS_XDBT`. This lets queries apply function `jcr:contains` to property `jcr:data` of a `jcr:content` node. Full-text indexes on other properties are not supported.

XML Schemas and JCR

Oracle XML DB Content Connector can create JCR node types from XML schemas.

This section has the following topics:

- Why Register XML Schemas for Use with JCR?
- How to Register an XML Schema with JCR
- How JCR Node Types are Generated from XML Schemas

Why Register XML Schemas for Use with JCR?

XML data can be stored in Oracle XML DB Repository as either file content or user-defined metadata. In either case, the XML data can be based on an XML schema. XML schema-based data is validated against an XML schema that has been registered with Oracle XML DB.

By default, the JCR nodes corresponding to XML document content and user-defined metadata are of node type `nt:unstructured`, a generic node type defined by JCR, even if the XML data is XML schema-based. Oracle XML DB Repository still validates any changes made through the Oracle XML DB Content Connector against the XML schema, but it is not possible to access or specify typing metadata through JCR.

However, Oracle XML DB Content Connector lets XML schemas be registered for use in JCR. This causes the content connector to generate JCR node types for the XML-schema simple types, complex types, and global element declarations in the registered XML schema.

In exposing XML data as JCR nodes, the content connector determines whether the XML data conforms to an XML schema registered for JCR use, based on the value of XML attribute `xsi:schemaLocation` or `xsi:noNamespaceSchemaLocation` of its root element. If the XML data conforms to a JCR registered XML schema, then the XML data is exposed as JCR nodes of the node types generated from the XML schema, instead of using the generic node type `nt:unstructured`.

You can also use the generated JCR node types to create or update XML document content and user-defined metadata.

Example 31–5 shows an XML document with XML schema-based content.

Example 31–5 XML Document with XML Schema-Based Content

```
<Address country="US"
   xmlns:xsi=
     "http://www.w3.org/2001/XMLSchema-instance"
   xsi:noNamespaceSchemaLocation=
     "http://www.example.com/Address">
  <name>Alice Smith</name>
  <street>123 Maple Street</street>
  <city>Mill Valley</city>
  <state>CA</state>
  <zip>90952</zip>
</Address>
```

The content of Example 31–5 is valid with respect to the XML schema shown in Example 31–6.

Example 31–6 XML Schema

```
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:complexType name="USAddress">
    <xsd:sequence>
      <xsd:element name="name"   type="xsd:string"/>
      <xsd:element name="street" type="xsd:string"/>
      <xsd:element name="city"   type="xsd:string"/>
      <xsd:element name="state"  type="xsd:string"/>
      <xsd:element name="zip"    type="xsd:long"/>
    </xsd:sequence>
    <xsd:attribute name="country" type="xsd:NMTOKEN"
                   fixed="US"/>
  </xsd:complexType>
</xsd:schema>
```

Initially, this XML schema is not registered for JCR use. The JCR nodes and properties representing the XML content are shown in Example 31–7.

Example 31–7 JCR Representation of XML Content Not Registered for JCR Use

```
ojcr:xmlContent (nt:unstructured)
  Address (nt:unstructured)
    country="US" (String)
    name (nt:unstructured)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="Alice Smith" (String)
    street (nt:unstructured)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="123 Maple Street" (String)
    city (nt:unstructured)
      jcr:xmltext(ojcr:xmltext)
```

```
        jcr:xmlcharacters="Mill Valley" (String)
    state (nt:unstructured)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="CA" (String)
    zip (nt:unstructured)
      jcr:xmltext (ojcr:xmltext)
        jcr:xmlcharacters="90952" (String)
```

The XML schema is then registered for JCR use. The JCR nodes and properties are shown in Example 31–8.

Example 31–8 JCR Representation of XML Content Registered for JCR Use

```
ojcr:xmlContent (nt:unstructured)
  Address (USAddress)
    country="US" (String)
    name (xsd:string)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="Alice Smith" (String)
    street (xsd:string)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="123 Maple Street" (String)
    city (xsd:string)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="Mill Valley" (String)
    state (xsd:string)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="CA" (String)
    zip (xsd:long)
      jcr:xmltext (ojcr:xmltext)
        jcr:xmlcharacters="90952" (Long)
```

Node `Address` now has node type `USAddress`. Similarly, nodes `name`, `street`, `city`, and `state` have node type `xsd:string`. Node `zip` has node type `xsd:long`, and the `jcr:xmlcharacters` property of its `jcr:xmltext` child is a `LONG` property type.

See Also: Chapter 29, "User-Defined Repository Metadata"

How to Register an XML Schema with JCR

Before you register an XML schema for use with JCR, you must register it for use with Oracle XML DB, using PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema`. For example, to register an XML schema with location `http://www.example.com/Address`, first register it for use with Oracle XML DB, as shown in Example 31–9. Then, register it for use with JCR, using Oracle XML DB Content Connector Java APIs, as shown in Example 31–10.

Example 31–9 Registering an XML Schema for Use with Oracle XML DB

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL       => 'http://www.example.com/Address',
    SCHEMADOC       => bfileContainingSchema,
    LOCAL           => FALSE,
    ENABLEHIERARCHY => DBMS_XMLSCHEMA.ENABLE_HIERARCHY_RESMETADATA);
END;
/
```

Note: You can use only globally registered XML schemas (`local => false`) with JCR.

Example 31–10 Registering an XML Schema for Use with JCR

```
import oracle.jcr.nodetype.OracleNodeTypeManager;
...
OracleNodeTypeManager ntm = (OracleNodeTypeManager)
  session.getWorkspace().getNodeTypeManager();

ntm.registerXMLSchema("http://www.example.com/Address", null);
```

The list of XML schemas registered for use with JCR is stored in the `OracleRepository` object. You can save this registration data by storing the `OracleRepository` object in a JNDI directory, as recommended by the JCR specification.

JCR requires that each node type have a unique name. By default, Oracle XML DB Content Connector generates JCR nodes types that correspond to a registered XML schema in the target namespace of the XML schema. If you wish to register two XML schemas with the same namespace, and the XML schemas declare types with the same names, you can avoid a name clash by overriding the namespace into which the JCR node types are generated. Refer to the Javadoc of method `registerXMLSchema()` for details.

See Also:

- "XML Schema Registration with Oracle XML DB" on page 17-7 for information about registering XML schemas with Oracle XML DB
- *Oracle Database XML Java API Reference*, package `oracle.jcr`, for information on Java method `registerXMLSchema()`

How JCR Node Types are Generated from XML Schemas

This section describes how Oracle XML DB Content Connector generates JCR node types from XML schemas that are registered for JCR use.

The type models of JCR and XML Schema are similar but not equivalent. Some aspects of XML Schema have no representation in JCR. For example, some constraining facets of an XML-schema simple type are not discoverable through JCR. They are enforced by Oracle XML DB Content Connector nonetheless.

More generally, the JCR node types generated from an XML schema do not augment, detract, or alter the XML schema validation performed when XML data that conforms to that XML schema is created or updated, whether through JCR or other interfaces.

Built-In Simple Types

A JCR node type is provided for each XML Schema built-in type. For example, the JCR node type `xsd:decimal` corresponds to the built-in type `xsd:decimal`.

The inheritance hierarchy of the JCR node types follows that of the built-in types. For example, `xsd:integer` is a subtype of `xsd:decimal`.

Each XML Schema built-in type maps to a JCR property value type, which is used to represent values of that type in JCR.

Table 31–2 XML Schema Built-In Types Mapped to JCR Property Value Types

XML Schema Built-in Type	JCR Property Value Type
xsd:anySimpleType	STRING
xsd:anyURI	STRING
xsd:base64Binary	BINARY
xsd:boolean	BOOLEAN
xsd:byte	LONG
xsd:date	DATE (1)
xsd:dateTime	DATE (1)
xsd:decimal	DOUBLE (2)
xsd:double	DOUBLE
xsd:duration	STRING
xsd:ENTITIES	STRING (3)
xsd:ENTITY	STRING
xsd:float	DOUBLE
xsd:gDay	STRING
xsd:gMonth	STRING
xsd:gMonthDay	STRING
xsd:gYear	STRING
xsd:gYearMonth	STRING
xsd:hexBinary	BINARY
xsd:ID	STRING
xsd:IDREF	STRING
xsd:IDREFS	STRING (3)
xsd:int	LONG
xsd:integer	LONG (2)
xsd:language	STRING
xsd:long	LONG
xsd:Name	STRING
xsd:NCName	STRING
xsd:negativeInteger	LONG
xsd:NMTOKEN	STRING
xsd:NMTOKENS	STRING (3)
xsd:nonNegativeInteger	LONG
xsd:nonPositiveInteger	LONG
xsd:normalizedString	STRING
xsd:NOTATION	STRING
xsd:positiveInteger	LONG
xsd:QName	STRING

Table 31–2 (Cont.) XML Schema Built-In Types Mapped to JCR Property Value Types

XML Schema Built-in Type	JCR Property Value Type
xsd:short	LONG
xsd:string	STRING
xsd:time	DATE (1)
xsd:token	STRING
xsd:unsignedByte	LONG
xsd:unsignedInt	LONG
xsd:unsignedLong	LONG
xsd:unsignedShort	LONG

Notes for Table 31–2:

1. The JCR DATE property type is accessed using java.util.Calendar objects. Since Calendar requires all fields to be set, a mask of 1970-01-01T00:00:00.000+00:00 is used to supply default values for missing fields when Property.getDate() or Value.getDate() is called. This includes omitted hour/minute/second values (for xsd:date), year/month/day values (for xsd:time), or time-zone values (for xsd:date, xsd:time, and xsd:dateTime). Calling Property.getString() or Value.getString() returns the unparsed string representation. Similarly, Property.setValue(String) or Property.setValue(valueFactory.createValue(String)) may be used to set DATE properties without applying the mask.
2. The value space of xsd:decimal and xsd:integer exceeds that of the corresponding JCR types, DOUBLE and LONG (accessed as Java double and long values). Consequently, some xsd:decimal and xsd:integer values can only be accessed in JCR as strings. For example, bigIntegerProperty.getLong() throws a javax.jcr.ValueFormatException, but bigIntegerProperty.getString() returns the unparsed string representation. Similarly, Property.setValue(String) or Property.setValue(valueFactory.createValue(String)) may be used to set DOUBLE or LONG properties to values outside the JCR value space.
3. xsd:ENTITIES, xsd:IDREFS, and xsd:NMTOKENS are represented in JCR as multi-valued STRING properties.

XML Schema-Defined Simple Types

A JCR node type is created for each simple type defined in an XML schema. The inheritance hierarchy of the JCR node types follows that of the XML schema types.

A derived-by-list simple type is represented by a multi-valued JCR property definition.

A derived-by-union simple type is represented by a JCR property definition with property type UNDEFINED.

The JCR node type corresponding to an anonymous simple type has a synthetic name anonymousNodeType#*sequenceNumber*. Your application should not rely on the synthesized name. It is not guaranteed to be the same across sessions, and it may change when an XML schema is registered or deregistered for JCR use or the definition of a registered XML schema is changed.

Complex Types

A JCR node type is created for each complex type defined in an XML schema. The inheritance hierarchy of the JCR node types follows that of the XML schema types.

For a JCR node type corresponding to an XML schema complex type:

- A property definition is created for each attribute declaration of the complex type. Attribute declarations or attribute groups referenced by name in a complex type are treated as though they were defined in line.
- A residual property definition is created if the complex type has an attribute wildcard.
- A child node definition is created for each uniquely-named element declaration in the complex type's content model. Element declarations or module groups referenced by name are treated as though they were defined in line. If an element declaration is the head of a substitution group, a child node definition is also created for each element declaration within the substitution group.
- A residual child node definition is created if the complex type has an element wildcard.
- A `jcr:xmltext` child node definition is created if the complex type permits XML text, either because `xsd:mixed = "true"` or it is an `xsd:simpleContent` definition.

The JCR node type for a complex type supports child node ordering.

It is not possible to determine whether a type was derived by extension or restriction using JCR.

The JCR node type corresponding to an anonymous complex type has a synthetic name `anonymousNodeType#`*`sequenceNumber`*. Your application should not rely on the synthesized name. It is not guaranteed to be the same across sessions, and it may change when an XML schema is registered or deregistered for JCR use or the definition of a registered XML schema is changed.

Global Element Declarations

A JCR node type is created for each global element declaration in an XML schema. The local name of the generated node type is formed by prepending an underscore (_) to the local name of the global element declaration. For example, in a namespace-qualified purchase order XML schema, a node type named `po:_purchaseOrder` is created for global element named `po:purchaseOrder`.

32

How to Write Oracle XML DB Applications in Java

This chapter describes how to write Oracle XML DB applications in Java. It includes design guidelines for writing Java applications including servlets, and how to configure the Oracle XML DB servlets.

This chapter contains these topics:

Overview of Oracle XML DB Java Applications

You can use Java code in these ways:

- In the database using the Java Virtual Machine (JVM).
- In a client or application server, using the OCI driver for JDBC.

Because Java runs in the database in the context of the database server process, the ways you can deploy and run Java code are restricted to the following:

- You can run Java code as a stored procedure invoked from SQL or PL/SQL.
- You can run a Java servlet.

Stored procedures are easier to integrate with SQL and PL/SQL code. They require Oracle Net Services as the protocol to access Oracle Database.

Servlets work better as the top-level entry point into Oracle Database, and require using HTTP(S) as the protocol to access Oracle Database.

Which Oracle XML DB APIs Are Available Inside and Outside the Database?

All Oracle XML DB application program interfaces (APIs) are available to applications running both in the server and outside the database, including:

- JDBC support for `XMLType`
- `XMLType` class
- Java DOM implementation

Design Guidelines: Java Inside or Outside the Database?

When choosing an architecture for writing Java Oracle XML DB applications, consider the following guidelines:

HTTP(S): Accessing Java Servlets or Directly Accessing XMLType Resources

If the downstream client wants to deal with XML in its textual representation, then using HTTP(S) to either access the Java servlets or directly access `XMLType` resources performs the best, especially if the XML node tree is not being manipulated much by the Java program.

The Java implementation in the server can natively move data from the database to the network without converting character data through UCS-2 Unicode (which is required by Java strings). In many cases data is copied directly from the database buffer cache to the HTTP(S) connection. There is no need to convert data from the buffer cache into the SQL serialization format used by Oracle Net Services, then move it to the JDBC client, and then convert to XML. Loading on demand and the LRU cache for `XMLType` are most effective inside the database server.

Accessing Many XMLType Object Elements: Use JDBC XMLType Support

If the downstream client is an application that programmatically accesses many or most of the elements of an `XMLType` instance using Java, then use JDBC `XMLType` support for best performance. It is often easier to debug Java programs outside of the database server, as well.

Use the Servlets to Manipulate and Write Out Data Quickly as XML

Oracle XML DB servlets are intended for writing HTTP stored procedures in Java that can be accessed using HTTP(S). They are not intended as a platform for developing an entire Internet application. In that case, the application servlet should be deployed in Oracle Fusion Middleware and access data in the database either using JDBC, or by using the `java.net.*` or similar APIs to get XML data through HTTP(S).

They are best used for applications that want to get into the database, manipulate the data, and write it out quickly as XML, not to format HTML pages for end-users.

Writing Oracle XML DB HTTP Servlets in Java

Oracle XML DB provides a protocol server that supports FTP, HTTP 1.1, WebDAV, and Java Servlets. Oracle XML DB supports Java Servlet version 2.2, with the following exceptions:

- The servlet WAR file (`web.xml`) is not supported in its entirety. Some `web.xml` configuration parameters must be handled manually. For example, creating roles must be done using the `SQL CREATE ROLE` command.

- `RequestDispatcher` and associated methods are *not* supported.
- Method `HTTPServletRequest.getCookies()` is *not* supported.
- Only one `ServletContext` (and one `web-app`) is currently supported.
- Stateful servlets (and thus the `HttpSession` class methods) are *not* supported. Servlets must maintain state in the database itself.

Configuration of Oracle XML DB Servlets

Oracle XML DB servlets are configured using the `xdbconfig.xml` file in Oracle XML DB Repository. Many of the XML elements in this file are the same as those defined by the Java Servlet 2.2 specification portion of Java 2 Enterprise Edition (J2EE), and have the same semantics. Table 32–1 lists the XML elements defined for the servlet deployment descriptor by the Java Servlet specification, along with extension elements supported by Oracle XML DB.

Table 32–1 XML Elements Defined for Servlet Deployment Descriptors

XML Element Name	Defined By	Supported?	Description	Comment
`auth-method`	Java	no	Specifies an HTTP authentication method required for access	N/A
`charset`	Oracle	yes	Specifies an IANA character set name	For example: ISO8859, UTF-8
`charset-mapping`	Oracle	yes	Specifies a mapping between a filename extension and a charset	N/A
`context-param`	Java	no	Specifies a parameter for a Web application	Not yet supported
`description`	Java	yes	A string for describing a servlet or Web application	Supported for servlets
`display-name`	Java	yes	A string to display with a servlet or Web application	Supported for servlets
`distributable`	Java	no	Indicates whether or not this servlet can function if all instances are not running in the same Java virtual machine	All servlets running in Oracle Database *must* be distributable.
`errnum`	Oracle	yes	Oracle error number	See *Oracle Database Error Messages*
`error-code`	Java	yes	HTTP(S) error code	Defined by RFC 2616
`error-page`	Java	yes	Defines a URL to redirect to if an error is encountered.	Can be specified through an HTTP(S) error, an uncaught Java exception, or through an uncaught Oracle error message
`exception-type`	Java	yes	Classname of a Java exception mapped to an error page	N/A
`extension`	Java	yes	A filename extension used to associate with MIME types, character sets, and so on.	N/A
`facility`	Oracle	yes	Oracle facility code for mapping error pages	For example: ORA, PLS, and so on.
`form-error-page`	Java	no	Error page for form login attempts	Not yet supported

Table 32–1 (Cont.) XML Elements Defined for Servlet Deployment Descriptors

XML Element Name	Defined By	Supported?	Description	Comment
`form-login-config`	Java	no	Config spec for form-based login	Not yet supported
`form-login-page`	Java	no	URL for the form-based login page	Not yet supported
`icon`	Java	Yes	URL of icon to associate with a servlet	Supported for servlets
`init-param`	Java	Yes	Initialization parameter for a servlet	N/A
`jsp-file`	Java	No	Java Server Page file to use for a servlet	Not supported
`lang`	Oracle	Yes	IANA language name	For example: en-US
`lang-mapping`	Oracle	Yes	Specifies a mapping between a filename extension and language content	N/A
`large-icon`	Java	Yes	Large sized icon for icon display	N/A
`load-on-startup`	Java	Yes	Specifies if a servlet is to be loaded on startup	N/A
`location`	Java	Yes	Specifies the URL for an error page	Can be a local path name or HTTP(S) URL
`login-config`	Java	No	Specifies a method for authentication	Not supported
`mime-mapping`	Java	Yes	Specifies a mapping between filename extension and the MIME type of the content	N/A
`mime-type`	Java	Yes	MIME type name for resource content	For example: text/xml or application/octet-stream
`OracleError`	Oracle	Yes	Specifies an Oracle error to associate with an error page	N/A
`param-name`	Java	Yes	Name of a parameter for a Servlet or `ServletContext`	Supported for servlets
`param-value`	Java	Yes	Value of a parameter	N/A
`realm-name`	Java	No	HTTP(S) realm used for authentication	Not supported
`role-link`	Java	Yes	Specifies a role a particular user must have for accessing a servlet	Refers to a database role name. Make sure to capitalize by default!
`role-name`	Java	Yes	A servlet name for a role	Just another name to call the database role. Used by the Servlet APIs
`security-role`	Java	No	Defines a role for a servlet to use	Not supported. You must manually create roles using the SQL `CREATE ROLE`
`security-role-ref`	Java	Yes	A reference between a servlet and a role	N/A

Table 32–1 (Cont.) XML Elements Defined for Servlet Deployment Descriptors

XML Element Name	Defined By	Supported?	Description	Comment
`servlet`	Java	Yes	Configuration information for a servlet	N/A
`servlet-class`	Java	Yes	Specifies the classname for the Java servlet	N/A
`servlet-language`	Oracle	Yes	Specifies the programming language in which the servlet is written.	Either Java, C, or PL/SQL. Currently, only Java is supported for customer-defined servlets.
`servlet-mapping`	Java	Yes	Specifies a filename pattern with which to associate the servlet	All of the mappings defined by Java are supported
`servlet-name`	Java	Yes	String name for a servlet	Used by servlet APIs
`servlet-schema`	Oracle	Yes	The Oracle Schema in which the Java class is loaded. If not specified, then the schema is searched using the default resolver specification.	If this is not specified, then the servlet must be loaded into the `SYS` schema to ensure that everyone can access it, or the default Java class resolver must be altered. Note that the servlet schema is capitalized unless the value is enclosed in double quotation marks.
`session-config`	Java	No	Configuration information for an `HTTPSession`	`HTTPSession` is not supported
`session-timeout`	Java	No	Timeout for an HTTP(S) session	`HTTPSession` is not supported
`small-icon`	Java	Yes	Small icon to associate with a servlet	N/A
`taglib`	Java	No	JSP tag library	JSPs currently not supported
`taglib-uri`	Java	No	URI for JSP tag library description file relative to file `web.xml`	JSPs currently not supported
`taglib-location`	Java	No	Path name relative to the root of the Web application where the tag library is stored	JSPs currently not supported
`url-pattern`	Java	Yes	URL pattern to associate with a servlet	See Section 10 of Java Servlet 2.2 spec
`web-app`	Java	No	Configuration for a Web application	Only one Web application is currently supported
`welcome-file`	Java	Yes	Specifies a welcome-file name	N/A
`welcome-file-list`	Java	Yes	Defines a list of files to display when a folder is referenced through an HTTP `GET` request	Example: `index.html`

Note:

- The following parameters defined for the `web.xml` file by Java are usable only by J2EE-compliant Enterprise Java Bean containers, and are not required for Java Servlet containers that do not support a full J2EE environment: `env-entry`, `env-entry-name`, `env-entry-value`, `env-entry-type`, `ejb-ref`, `ejb-ref-type`, `home`, `remote`, `ejb-link`, `resource-ref`, `res-ref-name`, res-type, `res-auth`.
- The following elements are used to define access control for resources: `security-constraint`, `web-resource-collection`, `web-resource-name`, `http-method`, `user-data-constraint`, `transport-guarantee`, `auth-constrain`. Oracle XML DB provides this functionality through access control lists (ACLs). An ACL is a list of access control entries (ACEs) that determines which principals have access to a given resource or resources. A future release will support using a `web.xml` file to generate ACLs.

See Also: Chapter 35, "Administration of Oracle XML DB" for more information about configuring the `xdbconfig.xml` file

HTTP Request Processing for Oracle XML DB Servlets

Oracle XML DB handles an HTTP request using the following steps:

1. If a connection has not yet been established, then Oracle Listener hands the connection to a shared server dispatcher.
2. When a new HTTP request arrives, the dispatcher wakes up a shared server.
3. The HTTP headers are parsed into appropriate structures.
4. The shared server attempts to allocate a database session from the Oracle XML DB session pool, if available, but otherwise creates a new session.
5. A new database call and a new database transaction are started.
6. If HTTP(S) has included authentication headers, then the session is authenticated as that database user (just as if the user logged into SQL*Plus). If no authentication information is included, and the request is `GET` or `HEAD`, then Oracle XML DB attempts to authenticate the session as the `ANONYMOUS` user. If that database user account is locked, then no unauthenticated access is allowed.
7. The URL in the HTTP request is matched against the servlets in the `xdbconfig.xml` file, as specified by the Java Servlet 2.2 specification.
8. The Oracle XML DB Servlet container is invoked in the Java VM inside Oracle. If the specified servlet has not been initialized yet, then the servlet is initialized.
9. The Servlet reads input from the `ServletInputStream`, and writes output to the `ServletOutputStream`, and returns from method `service()`.
10. If no uncaught Oracle error occurred, then the session is put back into the session pool.

See Also: Chapter 28, "Repository Access Using Protocols"

Session Pool and Oracle XML DB Servlets

Oracle Database uses one Java VM for each database session. A session that is reused from the session pool retains any state that is left over in the Java VM (Java static variables) from the last time that session was used.

This can be useful in caching Java state that is not user-specific, such as metadata, but Do not store secure user data in Java static memory. This could turn into a security hole inadvertently introduced by your application if you are not careful.

Native XML Stream Support

Node class `DOM` has an Oracle-specific method called `write()`, which takes the following arguments, returning void:

- `java.io.OutputStream` stream: A Java stream for writing the XML text.
- String `charEncoding`: The character encoding for writing the XML text. If `NULL`, then the database character set is used.
- `Short indent` The number of characters to indent nested XML elements.

Java method `write()` has a shortcut implementation if the stream provided is the `ServletOutputStream` provided inside the database. The contents of the Node are written in XML in native code directly to the output socket. This bypasses any conversions into and out of Java objects or Unicode (required for Java strings) and provides very high performance.

Oracle XML DB Servlet APIs

The APIs supported by Oracle XML DB servlets are defined by the Java Servlet 2.2 specification, the `Javadoc` for which is available at `http://download.oracle.com/javaee/1.2.1/api/index.html`

Table 32–2 lists Java Servlet 2.2 methods that are not implemented. They result in run-time exceptions.

Table 32–2 Java Servlet 2.2 Methods that Are Not Implemented

Interface	Methods Not Implemented
`HttpServletRequest`	`getSession(), isRequestedSessionIdValid()`
`HttpSession`	all
`HttpSessionBindingListener`	all

Oracle XML DB Servlet Example

Example 32–1 shows a simple servlet that prints the content of file resource `/public/test/foo1.text`.

Example 32–1 An Oracle XML DB Servlet

```
import javax.servlet.http.*;
import javax.servlet.*;
import java.util.*;
import java.io.*;
import java.util.*;
import java.io.IOException;
import java.io.OutputStreamWriter;
```

```
import java.io.Reader;
import java.io.Writer;
import java.sql.DriverManager;
import java.sql.SQLException;
import oracle.jdbc.OracleConnection;
import oracle.jdbc.OracleDriver;
import oracle.jdbc.OraclePreparedStatement;
import oracle.jdbc.OracleResultSet;
import oracle.sql.CLOB;
import oracle.xdb.XMLType;
import oracle.xdb.spi.XDBResource;

public class test extends HttpServlet {
  public void doGet(HttpServletRequest request, HttpServletResponse response)
    throws ServletException,
           IOException {
      try {
        try {
          // Get the database connection for the current HTTP session
          DriverManager.registerDriver(new oracle.jdbc.OracleDriver());
          OracleDriver ora = new OracleDriver();
          OracleConnection databaseConnection =
            (OracleConnection) ora.defaultConnection();
          String statementText =
            "SELECT XDBURIType('/public/test/foo1.txt').getClob() FROM DUAL";
          OraclePreparedStatement statement =
            (OraclePreparedStatement)
            databaseConnection.prepareStatement(statementText);
          OracleResultSet resultSet = null;
          CLOB content = null;
          // Execute the statement
          resultSet = (OracleResultSet) statement.executeQuery();
          while (resultSet.next())
            {// The statement returns a CLOB.
             // Copy content of CLOB to server's output stream.
             content = resultSet.getCLOB(1);
             Reader reader = content.getCharacterStream();
             Writer writer =
               new OutputStreamWriter(response.getOutputStream());
             int bytesSent = 0;
             int n;
             char[] buffer = new char[CLOB.MAX_CHUNK_SIZE];
             while (-1 != (n = reader.read(buffer)))
               { bytesSent = bytesSent + n;
                 writer.write(buffer, 0, n); }
             writer.flush();
             if (content.isOpen()) { content.close(); }}
          resultSet.close();
          statement.close();
          databaseConnection.close();
          response.getOutputStream().write('\n'); }
        catch (SQLException sql)
          { throw new ServletException(sql); }}
      catch (ServletException se )
        { se.printStackTrace(); }
      finally
        { System.out.flush(); }}}
```

To install the servlet, you compile it, then load it into Oracle Database:

```
% loadjava -grant public -u quine/curry -r test.class
```

Finally, register and map the servlet, associating it with a URL, as shown in Example 32–2.

Example 32–2 Registering and Mapping an Oracle XML DB Servlet

```
EXEC DBMS_XDB_CONFIG.addServlet('TestServletFoo', 'Java', 'TestServletFoo',
                                NULL, NULL, 'test', NULL, NULL, 'XDB');

EXEC DBMS_XDB_CONFIG.addServletMapping('/public/test/foo1.txt', 'TestServletFoo');

COMMIT;
```

33

Data Access Using URIs

This chapter describes how to generate and store URLs in the database and how to retrieve data pointed to by those URLs. Three kinds of URIs are discussed:

- DBUris – addresses to relational data in the database
- XDBUris – addresses to data in Oracle XML DB Repository
- HTTPUris – Web addresses that use the Hyper Text Transfer Protocol (HTTP(S))

This chapter contains these topics:

Overview of Oracle XML DB URL Features

The two main features described in this chapter are these:

- *Using paths as an indirection mechanism* – You can store a path in the database and then access its target *indirectly* by referring to the path. The paths in question are various kinds of Uniform Resource Identifier (URI).
- *Using paths that target database data to produce XML documents* – One kind of URI that you can use for indirection in particular, a *DBUri*, provides a convenient XPath notation for addressing *database data*. You can use a DBUri to construct an *XML document* that contains database data and whose structure reflects the database structure.

URIs and URLs

In developing Web-based XML applications, you often refer to data located on a network using **Uniform Resource Identifiers**, or **URI**s. A **URL**, or **Uniform Resource Locator**, is a URI that accesses an object using an Internet protocol.

A URI has two parts, separated by a number sign (**#**):

- A URL part, that identifies a document.
- A fragment part, that identifies a fragment within the document. The notation for the fragment depends on the document type. For HTML documents, it is an anchor name. For XML documents, it is an XPath expression.

These are typical URIs:

- *For HTML* – `http://www.example.com/document1#some_anchor`, where `some_anchor` is a named anchor in the HTML document.
- *For XML* – `http://www.example.com/xml_doc#/po/cust/custname`, where:
  - `http://www.example.com/xml_doc` identifies the location of the XML document.
  - `/po/cust/custname` identifies a fragment within the document. This portion is defined by the W3C XPointer recommendation.

See Also:

- `http://www.w3.org/2002/ws/Activity.html` an explanation of HTTP(S) URL notation
- `http://www.w3.org/TR/xpath` for an explanation of the XML XPath notation
- `http://www.w3.org/TR/xptr/` for an explanation of the XML XPointer notation
- `http://xml.coverpages.org/xmlMediaMIME.html` for a discussion of MIME types

URIType and its Subtypes

Oracle XML DB can represent paths of various kinds as database objects. These are the available path object types:

- **`HTTPURIType`** – An object of this type is called an **HTTPUri** and represents a URL that begins with **`http://`**. With `HTTPURIType`, you can create objects that represent links to remote *Web pages* (or files) and retrieve those Web pages by calling object methods. Applications using `HTTPUriType` must have the proper access privileges. `HTTPUriType` implements the Hyper Text Transfer Protocol (HTTP(S)) for accessing remote Web pages. `HTTPURIType` uses package `UTL_HTTP` to fetch data, so session settings and access control for this package can also be used to influence HTTP fetches.

  See Also:

  - "HTTPURIType PL/SQL Method GETCONTENTTYPE()" on page 33-5
  - *Oracle Database Security Guide* for information about managing fine-grained access to external network services

- **`DBURIType`** – An object of this type is called a **DBUri** and represents a URI that targets database data – a table, one or more rows, or a single column. With `DBURIType`, you can create objects that represent links to *database data*, and retrieve such data *as XML* by calling object methods. A DBUri uses a simple form of XPath expression as its URI syntax – for example, the following XPath expression is a

DBUri reference to the row of table `HR.employees` where column `first_name` has value `Jack`:

```
/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]
```

See Also : DBUris: Pointers to Database Data on page 33-12

- **`XDBURIType`** – An object of this type is called an **XDBUri**, and represents a URI that targets a resource in Oracle XML DB Repository. With PL/SQL constructor `XDBURIType` you can create objects that represent links to *repository resources*. You can then retrieve all or part of any resource by calling methods on those objects. The URI syntax for an XDBUri is a repository resource address, optionally followed by an XPath expression. For example, `/public/hr/doc1.xml#/purchaseOrder/lineItem` is an XDBUri reference to the `lineItem` child element of the root element `purchaseOrder` in repository file `doc1.xml` in folder `/public/hr`.

See Also : XDBUris: Pointers to Repository Resources on page 33-9

Each of these object types is derived from an *abstract* object type, **`URIType`**. As an abstract type, it has *no* instances (objects). Only its subtypes have instances.

Type `URIType` provides the following features:

- *Unified access to data stored inside and outside the server.* Because you can use `URIType` values to store pointers to HTTP(S) and DBUris, you can create queries and indexes without worrying about where the data resides.
- *Mapping of URIs in XML Documents to Database Columns.* When an XML document is broken up and stored in object-relational tables and columns, any URIs contained in the document are mapped to database columns of the appropriate `URIType` subtype.

You can reference data stored in relational columns and expose it to the external world using URIs. Oracle Database provides a standard servlet, DBUriServlet, that interprets DBUris. It also provides PL/SQL package `UTL_HTTP` and Java class `java.net.URL`, which you can use to fetch URL references.

`URIType` columns can be indexed natively in Oracle Database using Oracle Text – no special data store is needed.

See Also:

- "Create New Subtypes of URIType Using Package URIFACTORY" on page 33-19 for information about defining new `URIType` subtypes
- Chapter 6, "Indexes for XMLType Data"

DBUris and XDBUris – What For?

The following are typical uses of DBUris and XDBUris:

- You can reference XSLT stylesheets from within database-generated Web pages. PL/SQL package `DBMS_METADATA` uses DBUris to reference XSLT stylesheets. An XDBUri can be used to reference XSLT stylesheets stored in Oracle XML DB Repository.
- You can reference HTML text, images and other data stored in the database. URLs can be used to point to data stored in database tables or in repository folders.

- You can improve performance by bypassing the Web server. Replace a global URL in your XML document with a reference to the database, and use a servlet, a DBUri, or an XDBUri to retrieve the targeted content. Using a DBUri or an XDBUri generally provides better performance than using a servlet, because you interact directly with the database rather than through a Web server.
- With a DBUri, you can access an XML document in the database without using SQL.
- Whenever a repository resource is stored in a database table to which you have access, you can use either an XDBUri or a DBUri to access its content.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference*, "DBMS_METADATA package"

URIType Methods

Abstract object type `URIType` includes PL/SQL methods that can be used with each of its subtypes. Each of these methods can be overridden by any of the subtypes. Table 33–1 lists the `URIType` PL/SQL methods. In addition, each of the subtypes has a constructor with the same name as the subtype.

Table 33–1 URIType PL/SQL Methods

URIType Method	Description
`getURL()`	Returns the URL of the `URIType` instance. Use this method instead of referencing a URL directly. `URIType` subtypes override this method to provide the correct URL. For example, `HTTPURIType` stores a URL without prefix `http://`. Method `getURL()` then prepends the prefix and returns the entire URL.
`getExternalURL()`	Similar to `getURL()`, but `getExternalURL()` escapes characters in the URL, to conform with the URL specification. For example, spaces are converted to the escaped value `%20`.
`getContentType()`	Returns the MIME content type for the URI. *HTTPUri:* To return the content type, the URL is followed and the MIME header examined. *DBUri:* The returned content type is either `text/plain` (for a scalar value) or `text/xml` (otherwise). *XDBUri:* The value of the `ContentType` metadata property of the repository resource is returned.
`getCLOB()`	Returns the target of the URI as a `CLOB` instance. The database character set is used for encoding the data. *DBUri: XML* data is returned (unless node-test `text()` is used, in which case the targeted data is returned as is). When a `BLOB` column is targeted, the binary data in the column is *translated as hexadecimal character data*.
`getBLOB()`	Returns the target of the URI as a `BLOB` value. No character conversion is performed, and the character encoding is that of the URI target. This method can also be used to fetch binary data. *DBUri:* When applied to a DBUri that targets a `BLOB` column, `getBLOB()` returns the binary data *translated as hexadecimal character data*. When applied to a DBUri that targets *non*-binary data, the data is returned in the database character set.
`getXML()`	Returns the target of the URI as an `XMLType` instance. Using this, an application that performs operations other than `getCLOB()` and `getBLOB()` can use `XMLType` methods to do those operations. This throws an exception if the URI does not target a well-formed XML document.

Table 33–1 (Cont.) URIType PL/SQL Methods

URIType Method	Description
`createURI()`	Constructs an instance of one of the `URIType` subtypes.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

HTTPURIType PL/SQL Method GETCONTENTTYPE()

`HTTPURIType` PL/SQL method `getContentType()` returns the MIME information for its targeted document. You can use this information to decide whether to retrieve the document as a `BLOB` instance or a `CLOB` instance. For example, you might treat a Web page with a MIME type of `x/jpeg` as a `BLOB` instance, and one with a MIME type of `text/plain` or `text/html` as a `CLOB` instance.

Example 33–1 tests the HTTP content type to determine whether to retrieve data as a `CLOB` or `BLOB` instance. The content-type data is the HTTP header, for `HTTPURIType`, or the metadata of the database column, for `DBURIType`.

Example 33–1 Using HTTPURIType PL/SQL Method GETCONTENTTYPE()

```
DECLARE
  httpuri HTTPURIType;
  y CLOB;
  x BLOB;
BEGIN
  httpuri := HTTPURIType('http://www.oracle.com/index.html');
  DBMS_OUTPUT.put_line(httpuri.getContentType());
  IF httpuri.getContentType() = 'text/html'
  THEN
     y := httpuri.getCLOB();
  END IF;
  IF httpuri.getContentType() = 'application-x/bin'
  THEN
     x := httpuri.getBLOB();
  END IF;
END;
/
text/html
```

DBURIType PL/SQL Method GETCONTENTTYPE()

PL/SQL method `getContentType()` returns the MIME information for a URL. If a DBUri targets a scalar value, then the MIME content type returned is `text/plain`. Otherwise, the type returned is `text/xml`.

```
CREATE TABLE dbtab (a VARCHAR2(20), b BLOB);
```

DBUris corresponding to the following XPath expressions have content type `text/xml`, because each targets a complete column of XML data.

- `/HR/DBTAB/ROW/A`
- `/HR/DBTAB/ROW/B`

DBUris corresponding to the following XPath expressions have content type `text/plain`, because each targets a scalar value.

- `/HR/DBTAB/ROW/A/text()`
- `/HR/DBTAB/ROW/B/text()`

DBURIType PL/SQL Method GETCLOB()

When PL/SQL method `getCLOB()` is applied to a DBUri, the targeted data is returned as *XML* data, using the targeted column or table name as an XML element name. If the target XPath uses node-test `text()`, then the data is returned as text without an enclosing XML tag. In both cases, the returned data is in the database character set.

For example: If applied to a DBUri with XPath `/HR/DBTAB/ROW/A/text()`, where `A` is a non-binary column, the data in column `A` is returned as is. Without XPath node-test `text()`, the result is the data wrapped in XML:

```
<HR><DBTAB><ROW><A>...data_in_column_A...</A></ROW></DBTAB></HR>
```

When applied to a DBUri that targets a *binary* (`BLOB`) column, the binary data in the column is *translated as hexadecimal character data*.

For example: If applied to a DBUri with XPath `/HR/DBTAB/ROW/B/text()`, where `B` is a `BLOB` column, the targeted binary data is translated to hexadecimal character data and returned. Without XPath node-test `text()`, the result is the translated data wrapped in XML:

```
<HR><DBTAB><ROW><B>...data_translated_to_hex...</B></ROW></DBTAB></HR>
```

DBURIType PL/SQL Method GETBLOB()

When applied to a DBUri that targets a `BLOB` column, `getBLOB()` returns the binary data *translated as hexadecimal character data*. When applied to a DBUri that targets *non*-binary data, `getBLOB()` returns the data (as a `BLOB` value) in the database character set.

For example, consider table `dbtab`:

```
CREATE TABLE dbtab (a VARCHAR2(20), b BLOB);
```

When `getBLOB()` is applied to a DBUri corresponding to XPath expression `/HR/DBTAB/ROW/B`, it returns a `BLOB` value containing an XML document with root element `B` whose content is the hexadecimal-character translation of the binary data of column `B`.

When `getBLOB()` is applied to a DBUri corresponding to XPath expression `/HR/DBTAB/ROW/B/text()`, it returns a `BLOB` value containing only the hexadecimal-character translation of the binary data of column `B`.

When `getBLOB()` is applied to a DBUri corresponding to XPath expression `/HR/DBTAB/ROW/`**`A`**`/text()`, which targets *non*-binary data, it returns a `BLOB` value containing the data of column `A`, in the database character set.

Accessing Data Using URIType Instances

To use instances of `URIType` subtypes for indirection, you generally store such instances in the database and then use them in queries with a PL/SQL method such as `getCLOB()` to retrieve the targeted data. This section illustrates how to do this.

You can create database columns using `URIType` or any of its subtypes, or you can store just the text of each URI as a string and then create the needed `URIType` instances on demand, when the URIs are accessed. You can store objects of different `URIType` subtypes in the same `URIType` database column.

You can also define your own object types that inherit from the `URIType` subtypes. Deriving new types lets you use custom techniques to retrieve, transform, or filter data.

See Also:

- "Create New Subtypes of URIType Using Package URIFACTORY" on page 33-19 for information about defining new URIType subtypes
- "XSL Transformation and Oracle XML DB" on page 7-1 for information about transforming XML data

Example 33–2 stores an HTTPUri and a DBUri (instances of URIType subtypes HTTPURIType and DBURIType) in the same database column of type URIType. A query retrieves the data addressed by each of the URIs. The first URI is a Web-page URL. The second URI references data in table employees of standard database schema HR. (For brevity, only the beginning of the Web page is shown.)

Example 33–2 Creating and Querying a URI Column

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES (HTTPURIType.createURI('http://www.oracle.com'));
1 row created.

INSERT INTO uri_tab VALUES (DBURIType.createURI(
                              '/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
--------------------------------------------------------------------
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<html>
<head>
. . .

<?xml version="1.0"?>
 <ROW>
  <EMPLOYEE_ID>177</EMPLOYEE_ID>
  <FIRST_NAME>Jack</FIRST_NAME>
  <LAST_NAME>Livingston</LAST_NAME>
  <EMAIL>JLIVINGS</EMAIL>
  <PHONE_NUMBER>011.44.1644.429264</PHONE_NUMBER>
  <HIRE_DATE>23-APR-06</HIRE_DATE>
  <JOB_ID>SA_REP</JOB_ID>
  <SALARY>8400</SALARY>
  <COMMISSION_PCT>.2</COMMISSION_PCT>
  <MANAGER_ID>149</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>

2 rows selected.
```

To use URIType PL/SQL method createURI(), you must know the particular URIType subtype to use. PL/SQL method getURI() of package URIFACTORY lets you instead use the flexibility of late binding, determining the particular type information at run time.

PL/SQL factory method URIFACTORY.getURI() takes as argument a URI string. It returns a URIType instance of the appropriate subtype (HTTPURIType, DBURIType, or XDBURIType), based on the form of the URI string:

- If the URI starts with `http://`, then `getURI()` creates and returns an HTTPUri.
- If the URI starts with either `/oradb/` or `/dburi/`, then `getURI()` creates and returns a DBUri.
- Otherwise, `getURI()` creates and returns an XDBUri.

Example 33–3 is similar to Example 33–2, but it uses two different ways to obtain documents targeted by URIs:

- PL/SQL method `SYS.URIFACTORY.getURI()` with *absolute* URIs:
  - an HTTPUri that targets HTTP address `http://www.oracle.com`
  - a DBUri that targets database address `/oradb/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]`
- Constructor `SYS.HTTPURIType()` with a *relative* URL (no `http://`). The same HTTPUri is used as for the absolute URI: the Oracle home page.

In Example 33–3, the URI strings passed to `getURI()` are hard-coded, but they could just as easily be string values that are obtained by an application at run time.

Example 33–3 Using Different Kinds of URI, Created in Different Ways

```
CREATE TABLE uri_tab (docUrl SYS.URIType, docName VARCHAR2(200));
Table created.

-- Insert an HTTPUri with absolute URL into SYS.URIType using URIFACTORY.
-- The target is Oracle home page.
INSERT INTO uri_tab VALUES
  (SYS.URIFACTORY.getURI('http://www.oracle.com'), 'AbsURL');
1 row created.

-- Insert an HTTPUri with relative URL using constructor SYS.HTTPURIType.
-- Note the absence of prefix http://. The target is the same.
INSERT INTO uri_tab VALUES (SYS.HTTPURIType('www.oracle.com'), 'RelURL');
1 row created.

-- Insert a DBUri that targets employee data from table HR.employees.
INSERT INTO uri_tab VALUES
  (SYS.URIFACTORY.getURI('/oradb/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]'), 'Emp200');
1 row created.

-- Extract all of the documents.
SELECT e.docUrl.getCLOB(), docName FROM uri_tab e;

E.DOCURL.GETCLOB()
------------------
DOCNAME
-----------------------------------
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<html>
<head>
. . .
AbsURL

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
. . .
RelURL
```

```
<?xml version="1.0"?>
 <ROW>
  <EMPLOYEE_ID>200</EMPLOYEE_ID>
  <FIRST_NAME>Jennifer</FIRST_NAME>
  <LAST_NAME>Whalen</LAST_NAME>
  <EMAIL>JWHALEN</EMAIL>
  <PHONE_NUMBER>515.123.4444</PHONE_NUMBER>
  <HIRE_DATE>17-SEP-03</HIRE_DATE>
  <JOB_ID>AD_ASST</JOB_ID>
  <SALARY>4400</SALARY>
  <MANAGER_ID>101</MANAGER_ID>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
 </ROW>
Emp200

3 rows selected.

-- In PL/SQL
CREATE OR REPLACE FUNCTION returnclob
  RETURN CLOB
  IS a SYS.URIType;
BEGIN
  SELECT docUrl INTO a FROM uri_Tab WHERE docName LIKE 'Emp200%';
  RETURN a.getCLOB;
END;
/
Function created.

SELECT returnclob() FROM DUAL;

RETURNCLOB()
--------------------------------------------------------------------
<?xml version="1.0"?>
 <ROW>
  <EMPLOYEE_ID>200</EMPLOYEE_ID>
  <FIRST_NAME>Jennifer</FIRST_NAME>
  <LAST_NAME>Whalen</LAST_NAME>
  <EMAIL>JWHALEN</EMAIL>
  <PHONE_NUMBER>515.123.4444</PHONE_NUMBER>
  <HIRE_DATE>17-SEP-03</HIRE_DATE>
  <JOB_ID>AD_ASST</JOB_ID>
  <SALARY>4400</SALARY>
  <MANAGER_ID>101</MANAGER_ID>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
 </ROW>

1 row selected.
```

XDBUris: Pointers to Repository Resources

`XDBURIType` is a subtype of `URIType` that exposes resources in Oracle XML DB Repository using URIs. Instances of object type `XDBURIType` are called **XDBUris**.

XDBUri URI Syntax

The URL portion of an XDBUri URI is the hierarchical address of the targeted repository resource – it is a *repository* path (*not* an XPath expression).

The optional fragment portion of the URI uses the XPath syntax, and is separated from the URL part by a number-sign (#). It is appropriate only if the targeted resource is an *XML* document, in which case the fragment portion targets one or more parts of the XML document. If the targeted resource is not an XML document, then omit the fragment and number-sign.

The following are examples of XDBUri URIs:

- `/public/hr/image27.jpg`
- `/public/hr/doc1.xml#/PurchaseOrder/LineItem`

Based on the form of these URIs:

- `/public/hr` is a folder resource in Oracle XML DB Repository.
- `image27.jpg` and `doc1.xml` are resources in folder `/public/hr`.
- Resource `doc1.xml` is a file resource, and it contains an XML document.
- The XPath expression `/PurchaseOrder/LineItem` refers to the `LineItem` child element in element `PurchaseOrder` of XML document `doc1.xml`.

You can create an XDBUri using PL/SQL method `getURI()` of package `URIFACTORY`.

`XDBURIType` is the *default* `URIType` used when generating instances using `URIFACTORY` PL/SQL method `getURI()`, unless the URI has one of the recognized prefixes `http://`, `/dburi`, or `/oradb`.

For example, if resource `doc1.xml` is present in repository folder `/public/hr`, then the following query returns an XDBUri that targets that resource.

```
SELECT SYS.URIFACTORY.getURI('/public/hr/doc1.xml') FROM DUAL;
```

It is the lack of a special prefix that determines that the object type is `XDBURIType`, not any particular resource file extension or the presence of `#` followed by an XPath expression. Even if the resource were named `foo.bar` instead of `doc1.xml`, the returned `URIType` instance would still be an XDBUri.

XDBUri Examples

Example 33–4 creates an XDBUri, inserts values into a purchase-order table, and then selects all of the purchase orders. Because there is no special prefix used in the URI passed to `URIFACTORY.getURI()`, the created `URIType` instance is an XDBUri.

Example 33–4 Access a Repository Resource by URI Using an XDBUri

```
DECLARE
res BOOLEAN;
postring VARCHAR2(100):= '<?xml version="1.0"?>
<ROW>
<PO>999</PO>
</ROW>';
BEGIN
res:=DBMS_XDB_REPOS.createFolder('/public/orders/');
res:=DBMS_XDB_REPOS.createResource('/public/orders/po1.xml', postring);
END;
/
PL/SQL procedure successfully completed.

CREATE TABLE uri_tab (poUrl SYS.URIType, poName VARCHAR2(1000));
Table created.
```

```
-- Create an abstract type column so any type of URI can be used
-- Insert an absolute URL into poUrl.
-- The factory will create an XDBURIType because there is no prefix.
-- Here, po1.xml is an XML file that is stored in /public/orders/
-- of the XML repository.
INSERT INTO uri_tab VALUES
  (URIFACTORY.getURI('/public/orders/po1.xml'), 'SomePurchaseOrder');
1 row created.

-- Get all the purchase orders
SELECT e.poUrl.getCLOB(), poName FROM uri_tab e;

E.POURL.GETCLOB()
-----------------
PONAME
------
<?xml version="1.0"?>
<ROW>
<PO>999</PO>
</ROW>
SomePurchaseOrder

1 row selected.

-- Using PL/SQL, you can access table uri_tab as follows:
CREATE OR REPLACE FUNCTION returnclob
  RETURN CLOB
  IS a URIType;
BEGIN
  -- Get absolute URL for purchase order named like 'Some%'
   SELECT poUrl INTO a FROM uri_tab WHERE poName LIKE 'Some%';
   RETURN a.getCLOB();
END;
/
Function created.

SELECT returnclob() FROM DUAL;

RETURNCLOB()
--------------------
<?xml version="1.0"?>
<ROW>
<PO>999</PO>
</ROW>

1 row selected.
```

Because PL/SQL method `getXML()` returns an `XMLType` instance, you can use it with SQL/XML functions such as `XMLQuery`. The query in Example 33–5 illustrates this. The query retrieves all purchase orders numbered 999.

Example 33–5 Using PL/SQL Method GETXML() with XMLCAST and XMLQUERY

```
SELECT e.poUrl.getCLOB() FROM uri_tab e
  WHERE XMLCast(XMLQuery('$po/ROW/PO'
                         PASSING e.poUrl.getXML() AS "po"
                         RETURNING CONTENT)
                AS VARCHAR2(24))
        = '999';
```

```
E.POURL.GETCLOB()
--------------------
<?xml version="1.0"?>
<ROW>
<PO>999</PO>
</ROW>

1 row selected.
```

DBUris: Pointers to Database Data

A DBUri is a URI that targets *database data*. As for all instances of `URIType` subtypes, a DBUri provides an indirection mechanism for accessing data. In addition, `DBURIType` lets you do the following:

- Address database data using XPath notation. This, in effect, lets you visualize and access the database as if it were XML data.

  For example, a DBUri can use an expression such as `/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]` to target the row of table `HR.employees` where column `first_name` has value `Jack`.

- *Construct an XML document* that contains database data targeted by a DBUri and whose structure reflects the database structure.

  For example: A DBUri with XPath `/HR/DBTAB/ROW/A` can be used to construct an XML document that wraps the data of column `A` in XML elements that reflect the database structure and are named accordingly:

  ```
  <HR><DBTAB><ROW><A>...data_in_column_A...</A></ROW></DBTAB></HR>
  ```

A DBUri does not reference a global location as does an HTTPUri. You can, however, also access objects addressed by a DBUri in a global manner, by appending the DBUri to an HTTPUri that identifies a servlet that handles DBUris – see "DBUriServlet" on page 33-25.

Viewing the Database as XML Data

You can access only those database schemas to which you have been granted access privileges. This portion of the database is, in effect, your own view of the database.

Using `DBURIType`, you can have corresponding *XML* views of the database, which are portions of the database to which you have access, presented *in the form of XML data*. This means all kinds database data, not just data that is stored as XML. When visualized this way, the database data is effectively wrapped in XML elements, resulting in one or more XML documents.

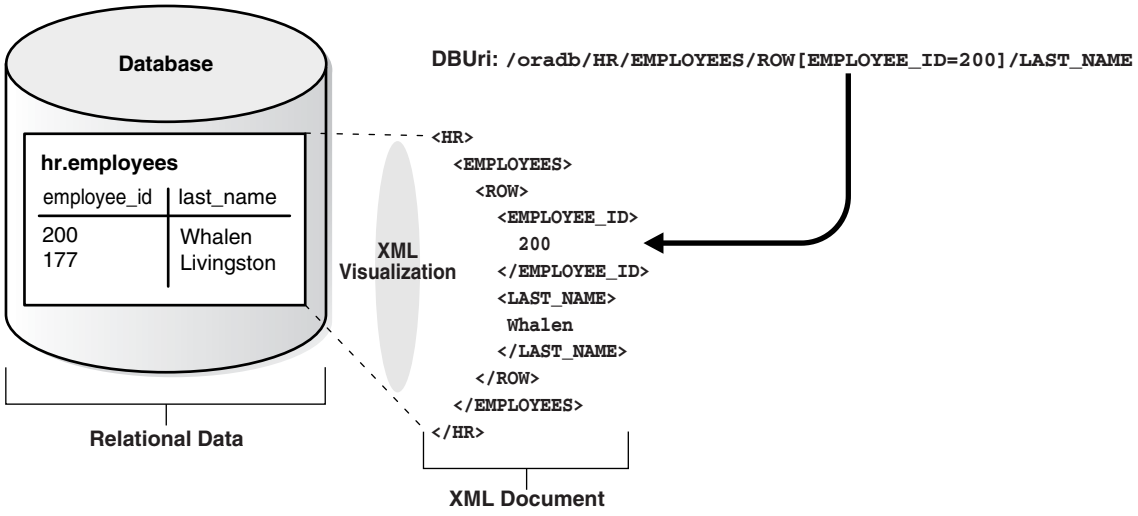
Such "XML views" are not database views, in the technical sense of the term. "View" here means only an abstract perspective that can be useful for understanding `DBURIType`. You can think of `DBURIType` as providing a way to visualize and access the database *as if it were* XML data.

However, `DBURIType` does not just provide an exercise in visualization and an additional means to access database data. Each "XML view" can be realized as an XML document – that is, you can use `DBURIType` to generate XML documents using database data.

All of this is another way of saying that `DBURIType` lets you use XPath notation to 1) address and access any database data to which you have access and 2) construct XML representations of that data.

Figure 33–1 illustrates the relation between a relational table, `HR.employees`, a corresponding XML view of a portion of that table, and the corresponding DBUri URI (a simple XPath expression). In this case, the portion of the data exposed as XML is the row where `employee_id` is `200`. The URI can be used to access the data and construct an XML document that reflects the "XML view".

Figure 33–1 A DBUri Corresponds to an XML Visualization of Relational Data



The XML elements in the "XML view" and the steps in the URI XPath expression both reflect the database table and column names. Note the use of **`ROW`** to indicate a row in the database table – both in the "XML view" and in the URI XPath expression.

Note also that the XPath expression contains a root-element step, **`oradb`**. This is used to indicate that the URI corresponds to a DBUri, not an HTTPUri or an XDBUri. Whenever this correspondence is understood from context, this XPath step can be skipped. For example, if it is known that the path in question is a path to database data, the following URIs are equivalent:

- **`/oradb`**`/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME`
- `/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME`

Whenever the URI context is not clear, however, you must use the prefix `/oradb` to distinguish a URI as corresponding to a DBUri. In particular, you must supply the prefix to `URIFACTORY` PL/SQL methods and to DBUriServlet.

See Also:

- "Create New Subtypes of URIType Using Package URIFACTORY" on page 33-19
- "DBUriServlet" on page 33-25
- Chapter 8, "Generation of XML Data from Relational Data" for other ways to generate XML from database data

DBUri URI Syntax

An XPath expression is a path into XML data that addresses one or more XML nodes. A DBUri exploits the notion of a virtual XML user visualization of the database to use a *simple form* of XPath expression as a URI to address database data. This is so, regardless of the type of data, in particular, whether or not the data is XML.

Thus, for DBURIType, Oracle Database supports only a subset of the full XPath or XPointer syntax. There are no syntax restrictions for XDBUri XPath expressions. There is also an exception in the DBUri case: data in XMLType tables. For an XMLType table, the simple XPath form is used to address the table itself within the database. Then, to address particular XML data in the table, the remainder of the XPath expression can use the full XPath syntax. This exception applies only to XMLType *tables*, not to XMLType columns.

In any case, unlike an XDBUri, a DBUri URI does not use a number-sign (#) to separate the URL portion of a URI from a fragment (XPath) portion. DBURIType does not use URI fragments. Instead, the entire URI is treated as a (simple) XPath expression.

You can create DBUris to any database data to which you have access. XPath expressions such as the following are allowed:

- */database_schema/table*
- */database_schema/table*/ROW[*predicate_expression*]/*column*
- */database_schema/table*/ROW[*predicate_expression*]/*object_column/attribute*
- */database_schema/**XMLType_table***/ROW/*XPath_expression*

In the last case, *XMLType_table* is an XMLType table, and *XPath_expression* is *any* XPath expression. For tables that are *not* XMLType, a DBUri XPath expression must end at a column (it cannot address specific data inside a column). This restriction includes XMLType columns, LOB columns, and VARCHAR2 columns that contain XML data.

A DBUri XPath expression can do any of the following:

- Target an entire table.

  For example, /HR/EMPLOYEES targets table employees of database schema HR.

- Include XPath predicates at any step in the path, except the database schema and table steps.

  For example, /HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/EMAIL targets column email of table HR.employees, where employee_id is 200.

- Use the text() XPath node test on data with scalar content. This is the *only* node test that can be used, and it cannot be used with the table or row step.

The following can be used in DBUri (XPath) *predicate* expressions:

- Boolean operators and, or, and not
- Relational operators <, >, <=, !=, >=, =, mod, div, * (multiply)

A DBUri XPath expression *must* do all of the following:

- Use only the *child* XPath axis – other axes, such as parent, are not allowed.
- Either specify a database schema or specify PUBLIC to resolve the table name without a specific schema.
- Specify a database view or table name.
- Include a ROW step, if a database column is targeted.
- Identify a *single* data value, which can be an object-type instance or a collection.
- Result in well-formed XML when it is used to generate XML data using database data.

An example of a DBUri that does *not* result in well-formed XML is `/HR/EMPLOYEES/ROW/LAST_NAME`. It returns more than one `<LAST_NAME>` element fragment, with no single root element.

- Use *none* of the following:
  - `*` (wildcard)
  - `.` (self)
  - `..` (parent)
  - `//` (descendant or self)
  - XPath functions, such as `count`

A DBUri XPath expression can optionally be prefixed by **`/oradb`** or **`/dburi`** (the two are equivalent) to distinguish it. This prefix is case-insensitive. However, the rest of the DBUri XPath expression is *case-sensitive*, as are XPath expressions generally. Thus, for example, to specify table `HR.employees` as a DBUri XPath expression, you must use `HR/EMPLOYEES`, not `hr/employees` (or a mixed-case combination), because table and column names are uppercase, by default.

See Also: `http://www.w3.org/TR/xpath` on XPath notation

DBUris are Scoped to a Database and Session

The content of the XML views you have of the database, and hence of the XML documents that you can construct, reflects the permissions you have for accessing particular database data at a given time. That is, a DBUri is scoped to a given database session, so the same DBUri can give different results in the same query, depending on the session context (which user is connected and what privileges the user has).

To complicate things a bit, there is also an XML element `PUBLIC`, under which database data is accessible without any database-schema qualification. This is a convenience feature, but it can also lead to some confusion if you forget that the XML views of the database for a given user depend on the specific access the user has to the database at a given time.

XML element `PUBLIC` corresponds to the use of a *public synonym*. For example, when queried by user `quine`, the following query tries to match table `foo` under database schema `quine`, but if no such table exists, it tries to match a public synonym named `foo`.

```
SELECT * FROM foo;
```

In the same way, XML element `PUBLIC` contains all of the database data visible to a given user and all of the data visible to that user through public synonyms. So, the same DBUri URI `/PUBLIC/FOO` can resolve to `quine.foo` when user `quine` is connected, and resolve to `curry.foo` when user `curry` is connected.

DBUri Examples

A DBUri can identify a table, a row, a column in a row, or an attribute of an object column. The following sections describe how to target different object types.

Targeting a Table

You can target a complete database table, using this syntax:

```
/database_schema/table
```

Example 33–6 uses a DBUri that targets a complete table. An XML document is returned that corresponds to the table contents. The top-level XML element is named for the table. The values of each row are enclosed in a ROW element.

Example 33–6 Targeting a Complete Table Using a DBUri

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES
       (DBURIType.createURI('/HR/EMPLOYEES'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
---------------
<?xml version="1.0"?>
<EMPLOYEES>
 <ROW>
  <EMPLOYEE_ID>100</EMPLOYEE_ID>
  <FIRST_NAME>Steven</FIRST_NAME>
  <LAST_NAME>King</LAST_NAME>
  <EMAIL>SKING</EMAIL>
  <PHONE_NUMBER>515.123.4567</PHONE_NUMBER>
  <HIRE_DATE>17-JUN-03</HIRE_DATE>
  <JOB_ID>AD_PRES</JOB_ID>
  <SALARY>24000</SALARY>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>101</EMPLOYEE_ID>
  <FIRST_NAME>Neena</FIRST_NAME>
  <LAST_NAME>Kochhar</LAST_NAME>
  <EMAIL>NKOCHHAR</EMAIL>
  <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
  <HIRE_DATE>21-SEP-05</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 . . .

1 row selected.
```

Targeting a Row in a Table

You can target one or more specific rows of a table, using this syntax:

/database_schema/table/ROW[*predicate_expression*]

Example 33–7 uses a DBUri that targets a single table row. The XPath predicate expression identifies the single table row that corresponds to employee number 200. The result is an XML document with ROW as the top-level element.

Example 33–7 Targeting a Particular Row in a Table Using a DBUri

```
CREATE TABLE uri_tab (url URIType);
Table created.
```

```
INSERT INTO uri_tab VALUES
       (DBURIType.createURI('/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
--------------------------------------------------------
<?xml version="1.0"?>
 <ROW>
  <EMPLOYEE_ID>200</EMPLOYEE_ID>
  <FIRST_NAME>Jennifer</FIRST_NAME>
  <LAST_NAME>Whalen</LAST_NAME>
  <EMAIL>JWHALEN</EMAIL>
  <PHONE_NUMBER>515.123.4444</PHONE_NUMBER>
  <HIRE_DATE>17-SEP-03</HIRE_DATE>
  <JOB_ID>AD_ASST</JOB_ID>
  <SALARY>4400</SALARY>
  <MANAGER_ID>101</MANAGER_ID>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
 </ROW>

1 row selected.
```

Targeting a Column

You can target a specific column, using this syntax:

/database_schema/table/ROW[*predicate_expression*]/*column*

You can target a specific attribute of an object column, using this syntax:

/database_schema/table/ROW[*predicate_expression*]/*object_column/attribute*

You can target a specific object column whose attributes have specific values, using this syntax:

/database_schema/table/ROW[*predicate_expression_with_attributes*]/*object_column*

Example 33–8 uses a DBUri that targets column `last_name` for the same employee as in Example 33–7. The top-level XML element is named for the targeted column.

Example 33–8 Targeting a Specific Column Using a DBUri

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES
       (DBURIType.createURI('/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
------------------------------
<?xml version="1.0"?>
 <LAST_NAME>Whalen</LAST_NAME>

1 row selected.
```

Example 33–9 uses a DBUri that targets a CUST_ADDRESS object column containing city and postal code attributes with certain values. The top-level XML element is named for the column, and it contains child elements for each of the object attributes.

Example 33–9 Targeting an Object Column with Specific Attribute Values Using a DBUri

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES
  (DBURIType.createURI(
     '/OE/CUSTOMERS/ROW[CUST_ADDRESS/CITY="Poughkeepsie" and
                        CUST_ADDRESS/POSTAL_CODE=12601]/CUST_ADDRESS'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
---------------
<?xml version="1.0"?>
 <CUST_ADDRESS>
  <STREET_ADDRESS>33 Fulton St</STREET_ADDRESS>
  <POSTAL_CODE>12601</POSTAL_CODE>
  <CITY>Poughkeepsie</CITY>
  <STATE_PROVINCE>NY</STATE_PROVINCE>
  <COUNTRY_ID>US</COUNTRY_ID>
 </CUST_ADDRESS>

1 row selected.
```

The DBUri identifies the object that has a CITY attribute with Poughkeepsie as value and a POSTAL_CODE attribute with 12601 as value.

Retrieving the Text Value of a Column

In many cases, it can be useful to retrieve only the text values of a column and not the enclosing tags. For example, if XSLT stylesheets are stored in a CLOB column, you can retrieve the document text without having any enclosing column-name tags. You can use the text() XPath node test for this. It specifies that you want only the text value of the node. Use the following syntax:

/oradb/*database_schema*/*table*/ROW[*predicate_expression*]/*column*/**text()**

Example 33–10 retrieves the text value of the employee last_name column for employee number 200, without the XML tags.

Example 33–10 Retrieve Only the Text Value of a Node Using a DBUri

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES
       (DBURIType.createURI(
          '/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME/text()'));

1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
```

```
---------------
Whalen

1 row selected.
```

Targeting a Collection

You can target a database collection, such as an ordered collection table. You must, however, target the entire collection – you cannot target individual members of a collection. When a collection is targeted, the XML document produced by the DBUri contains each collection member as an XML element, with all such elements enclosed in a element named for the *type* of the collection.

Example 33–11 uses a DBUri that targets a collection of numbers. The top-level XML element is named for the collection, and its children are named for the collection *type* (`NUMBER`).

Example 33–11 Targeting a Collection Using a DBUri

```
CREATE TYPE num_collection AS VARRAY(10) OF NUMBER;
/
Type created.

CREATE TABLE orders (item VARCHAR2(10), quantities num_collection);
Table created.

INSERT INTO orders VALUES ('boxes', num_collection(3, 7, 4, 9));
1 row created.

SELECT * FROM orders;

ITEM
----
QUANTITIES
----------
boxes
NUM_COLLECTION(3, 7, 4, 9)

1 row selected.

SELECT DBURIType('/HR/ORDERS/ROW[ITEM="boxes"]/QUANTITIES').getCLOB() FROM DUAL;

DBURITYPE('/HR/ORDERS/ROW[ITEM="BOXES"]/QUANTITIES').GETCLOB()
--------------------------------------------------------------
<?xml version="1.0"?>
 <QUANTITIES>
  <NUMBER>3</NUMBER>
  <NUMBER>7</NUMBER>
  <NUMBER>4</NUMBER>
  <NUMBER>9</NUMBER>
 </QUANTITIES>

1 row selected.
```

Create New Subtypes of URIType Using Package URIFACTORY

You can use PL/SQL package `URIFACTORY` to do more than create `URIType` instances. Additional PL/SQL methods are listed in Table 33–2.

Table 33–2 URIFACTORY PL/SQL Methods

PL/SQL Method	Description
`getURI()`	Returns the URL of the `URIType` instance.
`escapeURI()`	Escapes the URI string by replacing characters that are not permitted in URIs by their equivalent escape sequence.
`unescapeURI()`	Removes escaping from a given URI.
`registerURLHandler()`	Registers a particular type name for handling a particular URL. This is called by `getURI()` to generate an instance of the type. A Boolean argument can be used to indicate that the prefix must be stripped off before calling the appropriate type constructor.
`unregisterURLHandler()`	Unregisters a URL handler.

Of particular note is that you can use package `URIFACTORY` to define new subtypes of type `URIType`. You can then use those subtypes to provide specialized processing of URIs. In particular, you can define `URIType` subtypes that correspond to particular protocols – `URIFACTORY` then recognizes and processes instances of those subtypes accordingly.

Defining new types and creating database columns specific to the new types has these advantages:

- It provides an implicit *constraint* on the columns to contain only instances of those types. This can be useful for implementing specialized indexes on a column for specific protocols. For a DBUri, for instance, you can implement specialized indexes that fetch data directly from disk blocks, rather than executing SQL queries.
- You can have different constraints on different columns, based on the type. For a HTTPUri, for instance, you can define proxy and firewall constraints on a column, so that any access through the HTTP uses the proxy server.

Registering New URIType Subtypes with Package URIFACTORY

To provide specialized processing of URIs, you define and register a new URIType subtype, as follows:

1. Create the new type using SQL statement `CREATE TYPE`. The type must implement PL/SQL method `createURI()`.
2. Optionally override the default methods, to perform specialized processing when retrieving data or to transform the XML data before displaying it.
3. Choose a new URI prefix, to identify URIs that use this specialized processing.
4. Register the new prefix using PL/SQL method `registerURLHandler()`, so that package `URIFACTORY` can create an instance of your new subtype when it receives a URI starting with the new prefix you defined.

After the new subtype is defined, a URI with the new prefix is recognized by `URIFACTORY` methods, and you can create and use instances of the new type.

For example, suppose that you define a new protocol prefix, `ecom://`, and define a subtype of `URIType` to handle it. Perhaps the new subtype implements some special logic for PL/SQL method `getCLOB()`, or perhaps it makes some changes to XML tags or data in method `getXML()`. After you register prefix `ecom://` with `URIFACTORY`, a call to `getURI()` generates an instance of the new `URIType` subtype for a URI with that prefix.

Example 33–12 creates a new type, ECOMURIType, to handle a new protocol, ecom://. The example stores three different kinds of URIs in a single table: an HTTPUri, a DBUri, and an instance of the new type, ECOMURIType. To run this example, you would need to define each of the ECOMURIType member functions.

Example 33–12 URIFACTORY: Registering the ECOM Protocol

```
CREATE TABLE url_tab (urlcol varchar2(80));
Table created.

-- Insert an HTTP URL reference
INSERT INTO url_tab VALUES ('http://www.oracle.com/');
1 row created.

-- Insert a DBUri
INSERT INTO url_tab VALUES ('/oradb/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]');
1 row created.

-- Create a new type to handle a new protocol called ecom://
-- This is just an example template. For this to run, the implementations
-- of these functions must be specified.
CREATE OR REPLACE TYPE ECOMURIType UNDER SYS.URIType (
  OVERRIDING MEMBER FUNCTION getCLOB RETURN CLOB,
  OVERRIDING MEMBER FUNCTION getBLOB RETURN BLOB,
  OVERRIDING MEMBER FUNCTION getExternalURL RETURN VARCHAR2,
  OVERRIDING MEMBER FUNCTION getURI RETURN VARCHAR2,
  -- Must have this for registering with the URL handler
  STATIC FUNCTION createURI(url IN VARCHAR2) RETURN ECOMURIType);
/
-- Register a new handler for the ecom:// prefixes
BEGIN
  -- The handler type name is ECOMURIType; schema is HR
  -- Ignore the prefix case, so that URIFACTORY creates the same subtype
  -- for URIs beginning with ECOM://, ecom://, eCom://, and so on.
  -- Strip the prefix before calling PL/SQL method createURI(),
  -- so that the string 'ecom://' is not stored inside the
  -- ECOMURIType object. It is added back automatically when
  -- you call ECOMURIType.getURI().
  URIFACTORY.registerURLHandler (prefix => 'ecom://',
                                 schemaname => 'HR',
                                 typename => 'ECOMURITYPE',
                                 ignoreprefixcase => TRUE,
                                 stripprefix => TRUE);
END;
/
PL/SQL procedure successfully completed.

-- Insert this new type of URI into the table
INSERT INTO url_tab VALUES ('ECOM://company1/company2=22/comp');
1 row created.

-- Use the factory to generate an instance of the appropriate
-- subtype for each URI in the table.

-- You would need to define the member functions for this to work:
SELECT urifactory.getURI(urlcol) FROM url_tab;

-- This would generate:
HTTPURIType('www.oracle.com'); -- an HTTPUri
DBURIType('/oradb/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]', null); -- a DBUri
```

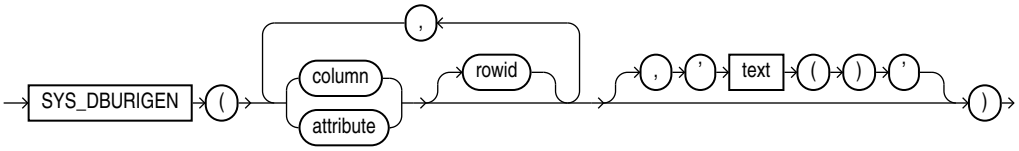
```
ECOMURIType('company1/company2=22/comp'); -- an ECOMURIType instance
```

SYS_DBURIGEN SQL Function

You can create a DBUri by providing an XPath expression to constructor `DBURIType` or to appropriate `URIFACTORY` PL/SQL methods. With Oracle SQL function `sys_DburiGen`, you can alternatively create a DBUri with an *XPath that is composed* from database columns and their values.

Oracle SQL function `sys_DburiGen` takes as its argument one or more database columns or attributes, and optionally a rowid, and generates a DBUri that targets a particular column or row object. Function `sys_DburiGen` takes an additional parameter that indicates whether the text value of the node is needed. See Figure 33–2.

Figure 33–2 SYS_DBURIGEN Syntax



All columns or attributes referenced must reside in the same table. They must each reference a unique value. If you specify multiple columns, then the initial columns identify the row, and the last column identifies the column within that row. If you do not specify a database schema, then the table name is interpreted as a public synonym.

See Also: *Oracle Database SQL Language Reference*

Example 33–13 uses Oracle SQL function `sys_DburiGen` to generate a DBUri that targets column `email` of table `HR.employees` where `employee_id` is `206`:

Example 33–13 SYS_DBURIGEN: Generating a DBUri that Targets a Column

```
SELECT sys_DburiGen(employee_id, email)
  FROM employees
  WHERE employee_id = 206;

SYS_DBURIGEN(EMPLOYEE_ID,EMAIL)(URL, SPARE)
--------------------------------------------------------------------------------
DBURITYPE('/PUBLIC/EMPLOYEES/ROW[EMPLOYEE_ID = "206"]/EMAIL', NULL)

1 row selected.
```

Rules for Passing Columns or Object Attributes to SYS_DBURIGEN

A column or attribute passed to Oracle SQL function `sys_DburiGen` must obey the following rules:

- *Same table:* All columns referenced in function `sys_DburiGen` must come from the same table or view.
- *Unique mapping:* The column or object attribute must be uniquely mappable back to the table or view from which it came. The only virtual columns allowed are those produced with `value` or `ref`. The column can come from a subquery with a SQL `TABLE` collection expression, that is, `TABLE(...)`, or from an inline view (as long as the inline view does not rename the columns).

See *Oracle Database SQL Language Reference* for information about the SQL `TABLE` collection expression.

- *Key columns:* Either the rowid or a set of key columns must be specified. The list of key columns is not required to be declared as a unique or primary key, as long as the columns uniquely identify a particular row in the result.
- **`PUBLIC`** *element:* If the table or view targeted by the rowid or key columns does not specify a database schema, then the `PUBLIC` keyword is used. When a DBUri is accessed, the table name resolves to the same table, synonym, or database view that was visible by that name when the DBUri was created.
- *Optional* **`text()`** *argument:* By default, `DBURIType` constructs an XML document. Use `text()` as the third argument to `sys_DburiGen` to create a DBUri that targets a text node (no XML elements). For example:

  ```
  SELECT sys_DburiGen(employee_id, last_name, 'text()') FROM hr.employees,
    WHERE employee_id=200;
  ```

  This constructs a DBUri with the following URI:

  ```
  /HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME/text()
  ```

- *Single-column argument:* If there is a single-column argument, then the column is used as both the key column to identify the row and the referenced column.

The query in Example 33–14 uses `employee_id` as both the key column and the referenced column. It generates a DBUri that targets the row with `employee_id` 200.

Example 33–14 Passing Columns with Single Arguments to SYS_DBURIGEN

```
SELECT sys_DburiGen(employee_id) FROM employees
  WHERE employee_id=200;

SYS_DBURIGEN(EMPLOYEE_ID)(URL, SPARE)
-------------------------------------
DBURITYPE('/PUBLIC/EMPLOYEES/ROW[EMPLOYEE_ID=''200'']/EMPLOYEE_ID', NULL)

1 row selected.
```

SYS_DBURIGEN SQL Function: Examples

Example 33–15 Inserting Database References Using SYS_DBURIGEN

```
CREATE TABLE doc_list_tab (docno NUMBER PRIMARY KEY, doc_ref SYS.DBURIType);
Table created.

-- Insert a DBUri that targets the row with employee_id=177
INSERT INTO doc_list_tab VALUES(1001, (SELECT sys_DburiGen(rowid, employee_id)
                                         FROM employees WHERE employee_id=177));
1 row created.

-- Insert a DBUri that targets the last_name column of table employees
INSERT INTO doc_list_tab VALUES(1002,
                                (SELECT sys_DburiGen(employee_id, last_name)
                                   FROM employees WHERE employee_id=177));
1 row created.

SELECT * FROM doc_list_tab;

     DOCNO
```

```
----------
DOC_REF(URL, SPARE)
--------------------------------------------------
      1001
DBURITYPE('/PUBLIC/EMPLOYEES/ROW[ROWID=''AAAQCcAAFAAAABSABN'']/EMPLOYEE_ID', NULL)

      1002
DBURITYPE('/PUBLIC/EMPLOYEES/ROW[EMPLOYEE_ID=''177'']/LAST_NAME', NULL)

2 rows selected.
```

Returning Partial Results

When selecting from a large column, you might sometimes want to retrieve only a portion of the result, and create a URL to the column instead. For example, consider the case of a travel story Web site. If travel stories are stored in a table, and users search for a set of relevant stories, then you do not want to list each entire story in the search-result page. Instead, you might show just the first 20 characters of each story, to represent the gist, and then return a URL to the full story. This can be done as follows:

Example 33–16 creates the travel story table.

Example 33–16 Creating the Travel Story Table

```
CREATE TABLE travel_story (story_name VARCHAR2(100), story CLOB);
Table created.

INSERT INTO travel_story
  VALUES ('Egypt', 'This is the story of my time in Egypt....');
1 row created.
```

Example 33–17 creates a function that returns only the first 20 characters from the story.

Example 33–17 A Function that Returns the First 20 Characters

```
CREATE OR REPLACE FUNCTION charfunc(clobval IN CLOB) RETURN VARCHAR2 IS
  res VARCHAR2(20);
  amount NUMBER := 20;
BEGIN
  DBMS_LOB.read(clobval, amount, 1, res);
  RETURN res;
END;
/
Function created.
```

Example 33–18 creates a view that selects only the first twenty characters from the travel story, and returns a DBUri to the story column.

Example 33–18 Creating a Travel View for Use with SYS_DBURIGEN

```
CREATE OR REPLACE VIEW travel_view AS
  SELECT story_name, charfunc(story) short_story,
         sys_DburiGen(story_name, story, 'text()') story_link
  FROM travel_story;
View created.

SELECT * FROM travel_view;

STORY_NAME
```

```
----------
SHORT_STORY
-----------
STORY_LINK(URL, SPARE)
----------------------
Egypt
This is the story of
DBURITYPE('/PUBLIC/TRAVEL_STORY/ROW[STORY_NAME=''Egypt'']/STORY/text()', NULL)

1 row selected.
```

RETURNING URLs to Inserted Objects

You can use Oracle SQL function `sys_DburiGen` in the `RETURNING` clause of DML statements to retrieve the URL of an object as it is inserted.

In Example 33–19, whenever a document is inserted into table `clob_tab`, its URL is inserted into table `uri_tab`. This is done using Oracle SQL function `sys_DburiGen` in the `RETURNING` clause of the `INSERT` statement.

Example 33–19 Retrieving a URL Using SYS_DBURIGEN in RETURNING Clause

```
CREATE TABLE clob_tab (docid NUMBER, doc CLOB);
Table created.

CREATE TABLE uri_tab (docs SYS.DBURIType);
Table created.
```

In PL/SQL, specify the storage of the URL of the inserted document as part of the insertion operation, using the `RETURNING` clause and `EXECUTE IMMEDIATE`:

```
DECLARE
  ret SYS.DBURIType;
BEGIN
  -- execute the insert operation and get the URL
  EXECUTE IMMEDIATE
    'INSERT INTO clob_tab VALUES (1, ''TEMP CLOB TEST'')
       RETURNING sys_DburiGen(docid, doc, ''text()'') INTO :1'
    RETURNING INTO ret;
  -- Insert the URL into uri_tab
  INSERT INTO uri_tab VALUES (ret);
END;
/

SELECT e.docs.getURL() FROM hr.uri_tab e;
E.DOCS.GETURL()
-----------------------------------------------
/ORADB/PUBLIC/CLOB_TAB/ROW[DOCID='1']/DOC/text()

1 row selected.
```

DBUriServlet

Oracle XML DB Repository resources can be retrieved using the HTTP server that is incorporated in Oracle XML DB. Oracle Database also includes a servlet, **DBUriServlet**, that makes any kind of database data available through HTTP(S) URLs. The data can be returned as plain text, HTML, or XML.

A Web client or application can access such data without using SQL or a specialized database API. You can retrieve the data by linking to it on a Web page or by requesting

it through HTTP-aware APIs of Java, PL/SQL, and Perl. You can display or process the data using an application such as a Web browser or an XML-aware spreadsheet. DBUriServlet can generate content that is XML data or not, and it can transform the result using XSLT stylesheets.

You make database data Web-accessible by using a URI that is composed of a servlet address (URL) plus a DBUri URI that specifies which database data to retrieve. This is the syntax, where `http://server:port` is the URL of the servlet (server and port), and `/oradb/database_schema/table` is the DBUri URI (any DBUri URI can be used):

```
http://server:port/oradb/database_schema/table
```

When using XPath notation in a URL for the servlet, you might need to escape certain characters. You can use `URIType` PL/SQL method `getExternalURL()` to do this.

You can either use `DBUriServlet`, which is pre-installed as part of Oracle XML DB, or write your own servlet that runs on a servlet engine. The servlet reads the URI portion of the invoking URL, creates a DBUri using that URI, calls `URIType` PL/SQL methods to retrieve the data, and returns the values in a form such as a Web page, an XML document, or a plain-text document.

The MIME type to use is specified to the servlet through the URI:

- By default, the servlet produces MIME types `text/xml` and `text/plain`. If the DBUri path ends in `text()`, then `text/plain` is used. Otherwise, an XML document is generated with MIME type `text/xml`.
- You can override the default MIME type, setting it to `binary/x-jpeg` or some other value, by using the `contenttype` argument to the servlet.

> **See Also:** Chapter 32, "How to Write Oracle XML DB Applications in Java", for information about Oracle XML DB servlets

Table 33–3 describes each of the optional URL parameters you can pass to DBUriServlet to customize its output.

Table 33–3 DBUriServlet: Optional Arguments

Argument	Description
`rowsettag`	Changes the default root tag name for the XML document. For example: `http://server:8080/oradb/HR/EMPLOYEES?rowsettag=OracleEmployees`
`contenttype`	Specifies the MIME type of the generated document. For example: `http://server:8080/oradb/HR/EMPLOYEES?contenttype=text/plain`
`transform`	Passes a URL to `URIFACTORY`, which retrieves the XSLT stylesheet at that location. This stylesheet is then applied to the XML document being returned by the servlet. For example: `http://server:8080/oradb/HR/EMPLOYEES?transform=/oradb/QUINE/XSLS/DOC/text()&contenttype=text/html`[1]

[1] This URL is split across two lines for the purpose of documentation.

Overriding the MIME Type Using a URL

To retrieve the `employee_id` column of the `employee` table, you can use a URL such as one of the following, where computer `server.oracle.com` is running Oracle Database with a Web service listening to requests on port 8080. Step `oradb` is the virtual path that maps to the servlet.

```
http://server.oracle.com:8080/oradb/QUINE/A/ROW[B=200]/C/text()
```

Produces a content type of text/plain

`http://server.oracle.com:8080/oradb/QUINE/A/ROW[B=200]/C`
Produces a content type of text/xml

To override the content type, you can use a URL that passes `text/html` to the servlet as the `contenttype` parameter:

`http://server.oracle.com:8080/oradb/QUINE/A/ROW[B=200]/C?contenttype=text/html`
Produces a content type of text/html

Customizing DBUriServlet

DBUriServlet is built into the database – to customize the servlet, you must edit the Oracle XML DB configuration file, `xdbconfig.xml`. You can edit it with database schema (user account) `XDB`, using WebDAV, FTP, Oracle Enterprise Manager, or PL/SQL. To update the file using FTP or WebDAV, download the document, edit it, and save it back into the database.

See Also:

- Chapter 32, "How to Write Oracle XML DB Applications in Java"
- Chapter 35, "Administration of Oracle XML DB"
- *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

DBUriServlet is installed at `/oradb/*`, which is the address specified in the `servlet-pattern` tag of `xdbconfig.xml`. The asterisk (`*`) is necessary to indicate that any path following `oradb` is to be mapped to the same servlet. `oradb` is published as the virtual path. You can change the path that is used to access the servlet.

In Example 33–20, the configuration file is modified to install DBUriServlet under `/dburi/*`. (The long XPath expression has been split here for documentation purposes. It actually needs to be on a single line.)

Example 33–20 Changing the Installation Location of DBUriServlet

```
DECLARE
  doc XMLType;
  doc2 XMLType;
BEGIN
  doc := DBMS_XDB_CONFIG.cfg_get();
  SELECT XMLQuery('declare default element namespace
                   "http://xmlns.oracle.com/xdb/xdbconfig.xsd";
                   copy $i := $doc modify
                   for $j in
$i/xdbconfig/sysconfig/protocolconfig/httpconfig/webappconfig/servletconfig/servlet-mappings[1]
/servlet-mapping[servlet-name="DBUriServlet"]/servlet-pattern
                   return replace value of node $j with $i/dburi/*
                   return $i'
                  PASSING DBMS_XDB_CONFIG.cfg_get() AS "doc"
                  RETURNING CONTENT) INTO doc2 FROM DUAL;
  DBMS_XDB_CONFIG.cfg_update(doc2);
  COMMIT;
END;
/
```

[1] This XQuery expression is split across two lines only for the purpose of documentation.

Security parameters, the servlet display-name, and the description can also be customized in configuration file `xdbconfig.xml`. The servlet can be removed by deleting its servlet-pattern. This can also be done using XQuery Update to update the servlet-mapping element to `NULL`.

DBUriServlet Security

Servlet security is handled by Oracle Database using roles. When users log in to the servlet, they use their database user name and password. The servlet checks to ensure that the user logging has one of the roles specified in the configuration file using parameter `security-role-ref`). By default, the servlet is available to role `authenticatedUser`, and any user who logs into the servlet with a valid database password has this role.

The role parameter can be changed to restrict access to any specific database roles. To change from the default `authenticatedUser` role to a role that you have created, you modify the Oracle XML DB configuration file.

Example 33–21 changes the default role `authenticatedUser` to role `servlet-users` (which you must have created).

Example 33–21 Restricting Servlet Access to a Database Role

```
DECLARE
  doc  XMLType;
  doc2 XMLType;
  doc3 XMLType;
BEGIN
  doc := DBMS_XDB_CONFIG.cfg_get();
  SELECT XMLQuery('copy $i := $p1 modify
                     (for $j in
$i/xdbconfig/sysconfig/protocolconfig/httpconfig/webappconfig/servletconfig/[2]
servlet-list/servlet[servlet-name="DBUriServlet"]/security-role-ref/role-name
                      return replace value of node $j with $p2)
                   return $i'
                  PASSING DOC AS "p1", 'servlet-users' AS "p2" RETURNING CONTENT)
    INTO doc2 FROM DUAL;
  SELECT XMLQuery('copy $i := $p1 modify
                      (for $j in
$i/xdbconfig/sysconfig/protocolconfig/httpconfig/webappconfig/servletconfig/
servlet-list/servlet[servlet-name="DBUriServlet"]/security-role-ref/role-link
                    return replace value of node $j with $p2)
                   return $i'
                  PASSING DOC2 AS "p1", 'servlet-users' AS "p2" RETURNING CONTENT)
    INTO doc3 FROM DUAL;
  DBMS_XDB_CONFIG.cfg_update(doc3);
  COMMIT;
END;
/
```

Configuring Package URIFACTORY to Handle DBUris

A URL such as `http://server/servlets/oradb` is handled by DBUriServlet (or by a custom servlet). When a URL such as this is stored as a `URIType` instance, it is generally desirable to use subtype `DBURIType`, since this URI targets database data.

[2] This XQuery expression is split across two lines only for the purpose of documentation.

However, if a URIType instance is created using PL/SQL methods of package URIFACTORY, then, by default, the subtype used is HTTPURIType, not DBURIType. This is because URIFACTORY looks only at the URI prefix, sees http://, and assumes that the URI targets a Web page. This results in unnecessary layers of communication and perhaps extra character conversions.

To make things more efficient, you can teach URIFACTORY that URIs of the given form represent database accesses and so should be realized as DBUris, not HTTPUris. You do this by registering a handler for this URI as a prefix, specifying DBURIType as the type of instance to generate.

Example 33–22 effectively tells URIFACTORY that any URI string starting with http://*server*/*servlets*/oradb corresponds to a database access.

Example 33–22 Registering a Handler for a DBUri Prefix

```
BEGIN
  URIFACTORY.registerURLHandler('http://server/servlets/oradb',
                                'SYS', 'DBURIType', true, true);
END;
/
```

After you execute this code, all getURI() calls in the same session automatically create DBUris for any URI strings with prefix http://*server*/*servlets*/oradb.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information about URIFACTORY functions

Table or View Access from a Browser Using DBUri Servlet

Oracle XML DB includes the DBUri servlet, which makes it possible to access the content of any table or view directly from a browser. DBUri servlet uses the facilities of the DBURIType to generate a simple XML document from the contents of the table. The servlet is C language-based and installed in the Oracle XML DB HTTP server. By default, the servlet is installed under the virtual directory /oradb.

The URL passed to the DBUri Servlet is an extension of the URL passed to the DBURIType. The URL is extended with the address and port number of the Oracle XML DB HTTP server and the virtual root that directs HTTP(S) requests to the DBUri servlet. The default configuration for this is /oradb.

The URL http://localhost:8080/oradb/HR/DEPARTMENTS would thus return an XML document containing the contents of the DEPARTMENTS table in the HR database schema. This assumes that the Oracle XML DB HTTP server is running on port 8080, the virtual root for the DBUri servlet is /oradb, and that the user making the request has access to the HR database schema.

DBUri servlet accepts parameters that allow you to specify the name of the ROW tag and MIME-type of the document that is returned to the client.

Content in XMLType table or view can also be accessed through the DBUri servlet. When the URL passed to the DBUri servlet references an XMLType table or XMLType view the URL can be extended with an XPath expression that can determine which documents in the table or row are returned. The XPath expression appended to the URL can reference any node in the document.

XML generated by DBUri servlet can be transformed using the XSLT processor built into Oracle XML DB. This lets XML that is generated by DBUri servlet be presented in a more legible format such as HTML.

See Also: "DBUriServlet" on page 33-25

XSLT stylesheet processing is initiated by specifying a transform parameter as part of the URL passed to DBUri servlet. The stylesheet is specified using a URI that references the location of the stylesheet within database. The URI can either be a `DBURIType` value that identifies a `XMLType` column in a table or view, or a path to a document stored in Oracle XML DB Repository. The stylesheet is applied directly to the generated XML before it is returned to the client. When using DBUri servlet for XSLT processing, it is good practice to use the `contenttype` parameter to explicitly specify the MIME type of the generated output.

If the XML document being transformed is stored as an XML schema-based `XMLType` instance, then Oracle XML DB can reduce the overhead associated with XSL transformation by leveraging the capabilities of the lazily loaded virtual DOM.

The root of the URL is `/oradb`, so the URL is passed to the DBUri servlet that accesses the `purchaseorder` table in the `SCOTT` database schema, rather than as a resource in Oracle XML DB Repository. The URL includes an XPath expression that restricts the result set to those documents where node `/PurchaseOrder/Reference/text()` contains the value specified in the predicate. The `contenttype` parameter sets the MIME type of the generated document to `text/xml`.

34

Native Oracle XML DB Web Services

This chapter contains these topics:

Overview of Native Oracle XML DB Web Services

Web services provide a standard way for applications to exchange information over the Internet and access services that implement business logic. Your applications can access Oracle Database using native Oracle XML DB Web services. One available service lets you issue SQL and XQuery queries and receive results as XML data. Another service provides access to all PL/SQL stored functions and procedures.

You can customize the input and output document formats when you use the latter service. If you do that then the WSDL is automatically generated by the native database Web services engine.

SOAP 1.1 is the version supported by Oracle XML DB. Applications use HTTP method `POST` to submit SOAP requests to native Oracle XML DB Web services. You can configure the locations of all native Oracle XML DB Web services and WSDL documents using the Oracle XML DB configuration file, `xdbconfig.xml`. You can also configure security settings for the Web services using the same configuration file.

You can use the `Accept-Charsets` field of the input HTTP header to specify the character set of Web-service responses. If this header field is omitted, then responses are in the database character set. The language of the input document and any error responses is the locale language of the database.

Error handling for native Oracle XML DB Web services uses the SOAP framework for faults.

See Also:

- http://www.w3.org/2002/ws/ for more information on Web services
- The W3C SOAP primer, http://www.w3.org/TR/2000/NOTE-SOAP-20000508, for more information on SOAP
- http://www.w3.org/TR/wsdl for information on the Web Services Description Language (WSDL)
- http://www.w3.org/TR/2003/REC-soap12-part0-20030624/#L11549 for information on SOAP fault handling
- "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4

Configuring and Enabling Web Services for Oracle XML DB

For security reasons, Oracle XML DB is not preconfigured with the native Web services enabled. To make native Oracle XML DB Web services available, you must have the Oracle XML DB HTTP server up and running, and you must explicitly add Web service configuration. Then, to allow specific users to use Web services, you must grant them appropriate roles.

1. Configure Web services – see "Configuring Web Services for Oracle XML DB".
2. Enable Web services for specific users, by granting them appropriate roles – "Enabling Web Services for Specific Users".

See Also: "HTTP(S) and Oracle XML DB Protocol Server" on page 28-18 for information about Oracle XML DB HTTP server

Configuring Web Services for Oracle XML DB

To make Web services available for Oracle XML DB, log on as user `SYS` and add the servlet configuration that is shown as the query output of Example 34–2 to your Oracle XML DB configuration file, `xdbconfig.xml`.

Example 34–1 shows how to use procedures in PL/SQL package `DBMS_XDB_CONFIG` to add the servlet. Example 34–2 shows how to verify that the servlet was added correctly.

Example 34–1 Adding a Web Services Configuration Servlet

```
DECLARE
  SERVLET_NAME VARCHAR2(32) := 'orawsv';
BEGIN
  DBMS_XDB_CONFIG.deleteServletMapping(SERVLET_NAME);
  DBMS_XDB_CONFIG.deleteServlet(SERVLET_NAME);
  DBMS_XDB_CONFIG.addServlet(
    NAME     => SERVLET_NAME,
    LANGUAGE => 'C',
    DISPNAME => 'Oracle Query Web Service',
    DESCRIPT => 'Servlet for issuing queries as a Web Service',
    SCHEMA   => 'XDB');
  DBMS_XDB_CONFIG.addServletSecRole(SERVNAME => SERVLET_NAME,
                                    ROLENAME => 'XDB_WEBSERVICES',
                                    ROLELINK => 'XDB_WEBSERVICES');
  DBMS_XDB_CONFIG.addServletMapping(PATTERN => '/orawsv/*',
```

```
                                                NAME     => SERVLET_NAME);
                END;
                /
```

Example 34–2 Verifying Addition of Web Services Configuration Servlet

```
XQUERY declare default element namespace "http://xmlns.oracle.com/xdb/xdbconfig.xsd"; (: :)
       (: This path is split over two lines for documentation purposes only.
          The path should actually be a single long line. :)
       for $doc in fn:doc("/xdbconfig.xml")/xdbconfig/sysconfig/protocolconfig/httpconfig/
        webappconfig/servletconfig/servlet-list/servlet[servlet-name='orawsv']
       return $doc
/

Result Sequence
-------------------------------------------------------------------------------
<servlet xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd">
  <servlet-name>orawsv</servlet-name>
  <servlet-language>C</servlet-language>
  <display-name>Oracle Query Web Service</display-name>
  <description>Servlet for issuing queries as a Web Service</description>
  <servlet-schema>XDB</servlet-schema>
  <security-role-ref>
    <description/>
    <role-name>XDB_WEBSERVICES</role-name>
    <role-link>XDB_WEBSERVICES</role-link>
  </security-role-ref>
</servlet>

1 item(s) selected.
```

See Also: "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4 for more information about configuring Oracle XML DB with `xdbconfig.xml`

Enabling Web Services for Specific Users

To enable Web services for a specific user, log on as user `SYS` and grant the role `XDB_WEBSERVICES` to the user. This role enables Web services over HTTPS. This role is *required* to be able to use Web services.

User `SYS` can, in *addition*, grant one or both of the following roles to the user:

- `XDB_WEBSERVICES_OVER_HTTP` – Enable use of Web services over HTTP (not just HTTPS).
- `XDB_WEBSERVICES_WITH_PUBLIC` – Enable access, using Web services, to database objects that are accessible to `PUBLIC`.

If a user is not granted `XDB_WEBSERVICES_WITH_PUBLIC`, then the user has access, using Web services, to all database objects (regardless of owner) that would normally be available to the user, *except* for `PUBLIC` objects. To make `PUBLIC` objects accessible to a user through Web services, `SYS` must grant role `XDB_WEBSERVICES_WITH_PUBLIC` to the user. With this role, a user can access any `PUBLIC` objects that would normally be available to the user if logged on to the database.

Querying Oracle XML DB Using a Web Service

The Oracle XML DB Web service for database queries is located at URL `http://`*`host`*`:`*`port`*`/`**`orawsv`**, where *`host`* and *`port`* are the host and HTTP(S) port

properties of your database. This Web service has a WSDL document associated with it that specifies the formats of the incoming and outgoing documents using XML Schema. This WSDL document is located at URL `http://host:port/orawsv?wsdl`.

Your application sends database queries to the Web service as XML documents that conform to the XML schema listed in Example 34–3.

Example 34–3 XML Schema for Database Queries To Be Processed by Web Service

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        targetNamespace="http://xmlns.oracle.com/orawsv">
  <element name="query">
    <complexType>
      <sequence>
        <element name="query_text">
          <complexType>
            <simpleContent>
              <extension base="string">
                <attribute name="type">
                  <simpleType>
                    <restriction base="NMTOKEN">
                      <enumeration value="SQL"/>
                      <enumeration value="XQUERY"/>
                    </restriction>
                  </simpleType>
                </attribute>
              </extension>
            </simpleContent>
          </complexType>
        </element>
        <choice maxOccurs="unbounded">
          <element name="bind">
            <complexType>
              <simpleContent>
                <extension base="string">
                  <attribute name="name" type="string"/>
                </extension>
              </simpleContent>
            </complexType>
          </element>
          <element name="bindXML" type="any"/>
        </choice>
        <element name="null_handling" minOccurs="0">
          <simpleType>
            <restriction base="NMTOKEN">
              <enumeration value="DROP_NULLS"/>
              <enumeration value="NULL_ATTR"/>
              <enumeration value="EMPTY_TAG"/>
            </restriction>
          </simpleType>
        </element>
        <element name="max_rows" type="positiveInteger" minOccurs="0"/>
        <element name="skip_rows" type="positiveInteger" minOccurs="0"/>
        <element name="pretty_print" type="boolean" minOccurs="0"/>
        <element name="indentation_width" type="positiveInteger" minOccurs="0"/>
        <element name="rowset_tag" type="string" minOccurs="0"/>
        <element name="row_tag" type="string" minOccurs="0"/>
        <element name="item_tags_for_coll" type="boolean" minOccurs="0"/>
      </sequence>
```

```
    </complexType>
  </element>
</schema>
```

This XML schema is contained in the WSDL document. The important parts of incoming query documents are as follows:

- `query_text` – The text of your query. Attribute `type` specifies the type of your query: either `SQL` or `XQUERY`.
- `bind` – A scalar bind-variable value. Attribute `name` names the variable.
- `bindXML` – An `XMLType` bind-variable value.
- `null_handling` – How `NULL` values returned by the query are to be treated:
  - `DROP_NULLS` – Put nothing in the output (no element). This is the default behavior.
  - `NULL_ATTR` – Use an empty element for `NULL`-value output. Use attribute `xsi:nil = "true"` in the element.
  - `EMPTY_TAG` – Use an empty element for `NULL`-value output, without a `nil` attribute.
- `max_rows` – The maximum number of rows to output for the query. By default, all rows are returned.
- `skip_rows` – The number of query output rows to skip, before including rows in the data returned in the SOAP message. You can use this in connection with `max_rows` to provide paginated output. The default value is zero (`0`).
- `pretty_print` – Whether the output document should be formatted for pretty-printing. The default value is `true`, meaning that the document is pretty-printed. When the value is `false`, no pretty-printing is done, and output rows are not broken with newline characters.
- `indentation_width` – The number of characters to indent nested elements that start a new line. The default value is one (`1`).
- `rowset_tag` – Name of the root element of the output document.
- `row_tag` – Name of the element whose value is a single row of query output.
- `item_tags_for_coll` – Whether to generate collection elements with name *`collection_name`*`_item`, where *`collection_name`* is the name of the collection.

These elements have the same meanings as corresponding parameters of procedures in PL/SQL package `DBMS_XMLGEN`.

Example 34–4 and Example 34–5 show the input and output of a simple SQL query.

Example 34–4 Input XML Document for SQL Query Using Query Web Service

```
<?xml version="1.0" ?>
<env:Envelope xmlns:env="http://www.w3.org/2002/06/soap-envelope ">
  <env:Body>
    <query xmlns="http://xmlns.oracle.com/orawsv">
      <query_text type="SQL">
        <![CDATA[SELECT * FROM employees WHERE salary = :e]>
      </query_text>
      <bind name="e">8300</bind>
      <pretty_print>false</pretty_print>
    </query>
  </env:Body>
```

```
</env:Envelope>
```

In Example 34–4, the query text is enclosed in `<![CDATA[...]>`. Although not strictly necessary in this example, it is appropriate to do this generally, because queries often contain characters such as < and >. Element `bind` is used to bind a value (`8300`) to the bind variable named `e`. Element `pretty_print` turns off pretty-printing of the output.

Example 34–5 Output XML Document for SQL Query Using Query Web Service

```
<?xml version="1.0"?>
<soap:Envelope xmlns:soap="http://www.w3.org/2002/06/soap-envelope">
<soap:Body>
<ROWSET><ROW><EMPLOYEE_ID>206</EMPLOYEE_ID><FIRST_NAME>William</FIRST_NAME><LAST_NAME>G
ietz</LAST_NAME><EMAIL>WGIETZ</EMAIL><PHONE_NUMBER>515.123.8181</PHONE_NUMBER><HIRE_DATE>07-JUN-
94</HIRE_DATE><JOB_ID>AC_ACCOUNT</JOB_ID><SALARY>8300</SALARY><MANAGER_ID>205</MANAGER_ID
><DEPARTMENT_ID>110</DEPARTMENT_ID></ROW></ROWSET>
</soap:Body>
</soap:Envelope>
```

Access to PL/SQL Stored Procedures Using a Web Service

The Oracle XML DB Web service for accessing PL/SQL stored functions and procedures is located at URL `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`package`*`/`*`fn_or_proc`* or, for a function or procedure that is not in a package (standalone), `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`fn_or_proc`*. Here, *`host`* and *`port`* are the host and HTTP(S) port properties of your database, *`fn_or_proc`* is the stored function or procedure name, *`package`* is the package it is in, and *`dbschema`* is the database schema owning that package.

The input XML document must contain the inputs needed by the function or procedure. The output XML document contains the return value and the values of all `OUT` variables.

The names of the XML elements in the input and output documents correspond to the variable names of the function or procedure. The generated WSDL document shows you the exact XML element names. This is the naming convention used:

- The XML element introducing the input to a PL/SQL function is named *`function-name`***`Input`**, where *`function-name`* is the name of the function (uppercase).
- The XML elements introducing input parameters for the function are named *`param-name`***`-`***`param-type`***`-`***`io-mode`**, where *`param-name`* is the name of the parameter (uppercase), *`param-type`* is its SQL data type, and *`io-mode`* is its input-output mode, as follows:
  - **`IN`** – `IN` mode
  - **`OUT`** – `OUT` mode
  - **`INOUT`** – `IN OUT` mode
- The XML element introducing the output from a PL/SQL function is named **`S`***`return-type`***`-`***`function-name`***`Output`**, where *`return-type`* is the SQL data type of the return value (uppercase), and *`function-name`* is the name of the function (uppercase).
- The XML elements introducing output parameters for the function are named the same as the output parameters themselves (uppercase). The element introducing the return value is named `RETURN`.

The return value of a function is in the `RETURN` element of the output document, which is always the first element in the document. This return-value position disambiguates it from any `OUT` parameter that might be named "`RETURN`".

Each stored function or procedure is associated with a separate, dynamic Web service that has its own, generated WSDL document. This WSDL document is located at URL `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`package`*`/`*`fn_or_proc`***`?wsdl`** or `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`fn_or_proc`***`?wsdl`**. In addition, you can optionally generate a single WSDL document to be used for all stored functions and procedures in a given package. The URL for that WSDL document is `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`package`***`?wsdl`**.

Data types in the incoming and outgoing XML documents are mapped to SQL data types for use by the stored function or procedure, according to Table 34–1. These are the only data types that are supported.

Table 34–1 Web Service Mapping Between XML and Oracle Database Data Types

Oracle Database Data Type	XML Schema Data Type
`CHAR`, `VARCHAR2`, `VARCHAR`	`xsd:string`
`DATE` – Dates must be in the database format.	`xsd:date`
`TIMESTAMP`, `TIMESTAMP WITH TIMEZONE`, `TIMESTAMP WITH LOCAL TIMEZONE`	`xsd:dateTime`
`INTERVAL YEAR TO MONTH`, `INTERVAL DAY TO SECOND`	`xsd:duration`
`NUMBER`, `BINARY_DOUBLE`, `BINARY_FLOAT`	`xsd:double`
`INT`, `INTEGER`, `SMALLINT`, `PLS_INTEGER`, `BINARY_INTEGER`	`xsd:integer`
`RAW`, `BLOB`, `REF`	`xsd:hexBinary`
PL/SQL `BOOLEAN`	`xsd:boolean`
Object types	`complexType`
`XMLType`	empty `complexType`

An object type is represented in XML as a complex-type element named the same as the object type. The object attributes are represented as children of this element.

Example of Using a PL/SQL Function with a Web Service

This section presents a simple PL/SQL function and its access using a Web service. The function takes as input a department ID and name, and it returns the salary total of all employees in the department. It also returns, as in-out and output parameters, respectively, the department name and the number of employees in the department. The default value of the department ID is `20`. In this simple example, the input value of the in-out parameter `dept_name` is not actually used. It is ignored, and the correct name is returned.

Example 34–6 shows the function definition. Example 34–7 shows the WSDL document that is created automatically from this function definition. Example 34–8 shows an input document that invokes the stored function. Example 34–9 shows the resulting output document.

Example 34–6 Definition of PL/SQL Function Used for Web-Service Access

```
CREATE OR REPLACE PACKAGE salary_calculator AUTHID CURRENT_USER AS
```

```
  FUNCTION TotalDepartmentSalary (dept_id    IN     NUMBER DEFAULT 20,
                                  dept_name  IN OUT VARCHAR2,
                                  nummembers OUT    NUMBER)
    RETURN NUMBER;
END salary_calculator;
/
CREATE OR REPLACE PACKAGE BODY salary_calculator AS
  FUNCTION TotalDepartmentSalary (dept_id    IN     NUMBER DEFAULT 20,
                                  dept_name  IN OUT VARCHAR2,
                                  nummembers OUT    NUMBER)
    RETURN NUMBER IS
      sum_sal NUMBER;
      BEGIN
        SELECT SUM(salary) INTO sum_sal FROM employees
          WHERE department_id = dept_id;
        SELECT department_name INTO dept_name FROM departments
          WHERE department_name = dept_name;
        SELECT count(*) INTO nummembers FROM employees
          WHERE department_id = dept_id;
    RETURN sum_sal;
  END;
END;
/
```

Example 34–7 WSDL Document Corresponding to a Stored PL/SQL Function

```
<definitions name="SALARY_CALCULATOR"
             targetNamespace="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR"
             xmlns="http://schemas.xmlsoap.org/wsdl/"
             xmlns:tns="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR"
             xmlns:xsd="http://www.w3.org/2001/XMLSchema"
             xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/">
  <types>
    <xsd:schema targetNamespace="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR"
                elementFormDefault="qualified">
      <xsd:element name="SNUMBER-TOTALDEPARTMENTSALARYInput">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="NUMMEMBERS-NUMBER-OUT">
              <xsd:complexType/>
            </xsd:element>
            <xsd:element name="DEPT_NAME-VARCHAR2-INOUT" type="xsd:string"/>
            <xsd:element name="DEPT_ID-NUMBER-IN" type="xsd:double"/>
          </xsd:sequence>
        </xsd:complexType>
      </xsd:element>
      <xsd:element name="TOTALDEPARTMENTSALARYOutput">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="RETURN" type="xsd:double"/>
            <xsd:element name="NUMMEMBERS" type="xsd:double"/>
            <xsd:element name="DEPT_NAME" type="xsd:string"/>
          </xsd:sequence>
        </xsd:complexType>
      </xsd:element>
    </xsd:schema>
  </types>
  <message name="TOTALDEPARTMENTSALARYInputMessage">
    <part name="parameters" element="tns:SNUMBER-TOTALDEPARTMENTSALARYInput"/>
  </message>
```

```
  <message name="TOTALDEPARTMENTSALARYOutputMessage">
    <part name="parameters" element="tns:TOTALDEPARTMENTSALARYOutput"/>
  </message>
  <portType name="SALARY_CALCULATORPortType">
    <operation name="TOTALDEPARTMENTSALARY">
      <input message="tns:TOTALDEPARTMENTSALARYInputMessage"/>
      <output message="tns:TOTALDEPARTMENTSALARYOutputMessage"/>
    </operation>
  </portType>
 <binding name="SALARY_CALCULATORBinding" type="tns:SALARY_CALCULATORPortType">
    <soap:binding style="document" transport="http://schemas.xmlsoap.org/soap/http"/>
    <operation name="TOTALDEPARTMENTSALARY">
      <soap:operation soapAction="TOTALDEPARTMENTSALARY"/>
      <input>
        <soap:body parts="parameters" use="literal"/>
      </input>
      <output>
        <soap:body parts="parameters" use="literal"/>
      </output>
    </operation>
  </binding>
  <service name="SALARY_CALCULATORService">
    <documentation>Oracle Web Service</documentation>
    <port name="SALARY_CALCULATORPort" binding="tns:SALARY_CALCULATORBinding">
      <soap:address location="httpS://example:8088/orawsv/HR/SALARY_CALCULATOR"/>
     </port>
  </service>
</definitions>
```

Example 34–8 Input XML Document for PL/SQL Query Using Web Service

```
<?xml version="1.0" ?><soap:Envelope
xmlns:soap="http://www.w3.org/2002/06/soap-envelope"><soap:Body><SNUMBER-
TOTALDEPARTMENTSALARYinput
xmlns="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR/TOTALDEPARTMENTSALARY">
<DEPT_ID-NUMBER-IN>30</DEPT_ID-NUMBER-IN><DEPT_NAME-VARCHAR2-INOUT>Purchasing
</DEPT_NAME-VARCHAR2-INOUT><NUMMEMBERS-NUMBER-OUT/></SNUMBER-
TOTALDEPARTMENTSALARYinput></soap:Body></soap:Envelope>
```

Example 34–9 Output XML Document for PL/SQL Query Using Web Service

```
<?xml version="1.0" ?>
<soap:Envelope xmlns:soap="http://www.w3.org/2002/06/soap-envelope">
  <soap:Body>
    <TOTALDEPARTMENTSALARYOutput
       xmlns="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR/TOTALDEPARTMENTSALARY">
      <RETURN>24900</RETURN>
      <NUMMEMBERS>6</NUMMEMBERS>
      <DEPT_NAME>Purchasing</DEPT_NAME>
    </TOTALDEPARTMENTSALARYOutput>
  </soap:Body>
</soap:Envelope>
```

Part VII

Oracle Tools that Support Oracle XML DB

Part VII of this manual provides information about Oracle tools that you can use with Oracle XML DB. It describes tools for managing Oracle XML DB, loading XML data, and exchanging XML data.

Part VI contains the following chapters:

35

Administration of Oracle XML DB

This chapter describes how to administer Oracle XML DB. It includes information about installing, upgrading, and configuring Oracle XML DB.

This chapter contains these topics:

- Upgrade or Downgrade of an Existing Oracle XML DB Installation
- Administration of Oracle XML DB Using Oracle Enterprise Manager
- Configuration of Oracle XML DB Using xdbconfig.xml

> **See Also:** "Configuration of Repository Resources for XLink and XInclude" on page 23-9 for information on configuring Oracle XML DB Repository resources for use with XLink and XInclude

Upgrade or Downgrade of an Existing Oracle XML DB Installation

The following considerations apply to all upgrades of Oracle Database from a release prior to Oracle Database 12*c* Release 1 (12.1.0.1):

- Run script `catproc.sql`, as always.
- Replication of hierarchy-enabled tables is not supported for any replication method, including rolling upgrade.
- If supplemental logging is turned on then these operations are not supported:
  - Use of the `APPEND` hint for `INSERT`
  - SQL*Loader direct-path insertion of `XMLType` data
- If you use rolling upgrade and any of the following operations are invoked on the primary database, then an *unsupported operation* error is raised on the standby database:
  - `DBMS_XDB_ADMIN`—all operations
  - `DBMS_XMLSCHEMA.copyEvolve`
  - `DBMS_XMLSCHEMA.compileSchema`
  - `DBMS_XMLINDEX.dropparameter`
  - `DBMS_XMLINDEX.modifyparameter`
  - `DBMS_XMLINDEX.registerparameter`
- ACL security: In releases prior to Oracle Database 11*g* Release 1, conflicts among ACEs for the same principal and same privilege were resolved by giving priority to any ACE that had child `deny`, whether or not preceding ACEs had child `grant`,

that is, ACE order did not matter. In Oracle Database 11*g* and later this `deny-trumps-grant` behavior is still available, but it is not the default behavior.

- Prior to Oracle Database 12*c* Release 1 (12.1.0.1), basic access authentication was the only available HTTP authentication mechanism. Starting with 12*c* Release 1, digest access authentication is available. See "Authentication Considerations for Database Installation, Upgrade and Downgrade" on page 35-2 for authentication considerations that apply to database upgrades and downgrades.

See Also:

- *Oracle Data Guard Concepts and Administration* for information about performing a rolling upgrade
- "ACL and ACE Evaluation" on page 27-8 for information about conflicts among ACEs

Authentication Considerations for Database Installation, Upgrade and Downgrade

The following sections detail authentication considerations that apply to database installation, upgrades and downgrades.

See Also: "Configuration and Management of Authentication Mechanisms for HTTP" on page 28-9 for how to configure authentication

Authentication Considerations for a Database Installation

In a default database installation, digest authentication is enabled, and basic authentication is disallowed. Digest verifiers are automatically generated for *all* users.

Authentication Considerations for a Database Upgrade

After an upgrade from a release prior to Oracle Database 12*c* Release 1 (12.1.0.1), digest authentication is appended to the list of allowed authentication mechanisms. But basic authentication remains the current authentication method if it was enabled before the upgrade.

This is for backward compatibility *only*: Oracle recommends that your database administrator *disable basic authentication as soon as possible* after upgrading. The reason that basic authentication remains in effect after such an upgrade is to allow users to change their passwords using a Web browser that does not support digest authentication.

For such an upgrade, digest verifiers are computed for all *new* users and for all previously existing *users whose passwords changed* during the upgrade. Other users do *not* have digest verifiers.

After an upgrade, a DBA can use database view `DBA_DIGEST_VERIFIERS` to check which users have digest verifiers and take appropriate action, as follows:

1. Configure *basic* authentication as the *first* allowed authentication mechanism in the Oracle XML DB configuration file, `xdbconfig.xml`. This ensures that basic authentication can be used for HTTP access.
2. Expire all passwords for those users who do not have digest verifiers. This query returns those users:

```
SELECT USERNAME FROM DBA_DIGEST_VERIFIERS
  WHERE HAS_DIGEST_VERIFIERS = 'NO' AND DIGEST_TYPE is NULL;
```

3. After the passwords for all such users have been changed, configure `xdbconfig.xml` to re-enable digest as the first or (preferably) the only allowed authentication mechanism.

Authentication Considerations for a Database Downgrade

If you downgrade to a release where digest authentication was not supported, digest authentication is disabled and made unavailable as an authentication choice.

All digest verifiers are *erased* during a downgrade. This means, in particular, that if a downgrade is followed by an upgrade then users who were able to authenticate prior to the downgrade are denied digest authentication after the downgrade and the subsequent upgrade.

Automatic Installation of Oracle XML DB

If Oracle XML DB is not already installed in your database prior to an upgrade to Oracle Database 12*c* Release 1 (12.1.0.1) or later, then it is automatically installed in tablespace `SYSAUX` during the upgrade.

If Oracle XML DB has thus been automatically installed, and if you want to use Oracle XML DB, then, after the upgrade operation, you must set the database compatibility to at least 12.1.0.1. If the compatibility is less than 12.1.0.1 then an error is raised when you try to use Oracle XML DB.

If Oracle XML DB was automatically installed during an upgrade and the current compatibility level is less than 12.1.0.1, then Oracle DB is automatically uninstalled during any downgrade to a prior release.

Validation of ACL Documents and Configuration File

Access control list (ACL) documents are stored in table `XDB$ACL`. The Oracle XML DB configuration file, `xdbconfig.xml`, is stored in table `XDB$CONFIG`. Starting with Oracle Database 12*c* Release 1 (12.1.0.1), these tables use the post-parse (binary XML) storage model. This implies that ACL documents and the configuration file are fully validated against their respective XML schemas. Validation takes place during upgrade, using your existing ACL documents and configuration file and the corresponding existing XML schemas.

If an ACL document fails to validate during upgrade, then the document is moved to table `XDB$INVALID_ACL`.

If validation of configuration file `xdbconfig.xml` fails during upgrade, then the file is saved in table `XDB$INVALID_CONFIG`, the default configuration file replaces it in table `XDB$CONFIG`, and the `XDB` component of the database is marked invalid. You must then start the database in normal mode and fix the `XDB` component, before trying to use the database.

To fix the `XDB` component, you can fix the invalid files to make them valid, and then call PL/SQL procedure `RecoverUpgrade`. After validating, this procedure moves the fixed files to tables `XDB$ACL` and `XDB$CONFIG`, and marks the `XDB` component valid.

As an option, you can call procedure `RecoverUpgrade` with parameter `use_default` set to `TRUE`, to abandon any invalid files. In this case, any valid files are moved to tables `XDB$ACL` and `XDB$CONFIG`, and any remaining invalid files are deleted. Default files are used in place of any invalid files. For ACLs, the default ACL document is used. For the configuration file, the default `xdbconfig.xml` is used (in which ACE order matters).

Caution: Use a `TRUE` value for parameter `use_default` *only* if you are certain that you no longer need the old ACL files or configuration file that are invalid. These files are *deleted*.

Administration of Oracle XML DB Using Oracle Enterprise Manager

Oracle Enterprise Manager is a graphical tool supplied with Oracle Database that lets you perform database administration tasks easily. You can use it to perform the following tasks related to Oracle XML DB:

- Configure Oracle XML DB. View or edit parameters for the Oracle XML DB configuration file, `xdbconfig.xml`.

  For information about configuring Oracle XML DB without using Oracle Enterprise Manager, see "Configuration of Oracle XML DB Using xdbconfig.xml" on page 35-4.

- Search, create, edit, undelete Oracle XML DB Repository *resources* and their associated *access control lists* (ACLs).

  For information about creating and managing resources without using Oracle Enterprise Manager, see Part VI, "Oracle XML DB Repository".

- Search, create, edit, and delete `XMLType` *tables* and *views*.

- Search, create, register, and delete *XML schemas*.

  For information about manipulating XML schemas without using Oracle Enterprise Manager, see Chapter 17, "XML Schema Storage and Query: Basic".

- Create *function-based indexes* based on XPath expressions.

  For information about creating function-based indexes without using Oracle Enterprise Manager, see Chapter 6, "Indexes for XMLType Data".

  See Also: The online help available with Oracle Enterprise Manager, for information about using Enterprise Manager to perform these tasks

Configuration of Oracle XML DB Using xdbconfig.xml

Oracle XML DB is managed internally through a configuration file, `xdbconfig.xml`, which is stored as a resource in Oracle XML DB Repository. As an alternative to using Oracle Enterprise Manager to configure Oracle XML DB, you can configure it directly using the Oracle XML DB configuration file.

The configuration file can be modified at run time. Updating the configuration file creates a new version of this repository resource. At the start of each session, the current version of the configuration file is bound to that session. The session uses this configuration-file version for its duration, unless you make an explicit call to refresh the session to the latest version.

Oracle XML DB Configuration File, xdbconfig.xml

The configuration of Oracle XML DB is defined and stored in an Oracle XML DB Repository resource, `xdbconfig.xml`, which conforms to the Oracle XML DB configuration XML schema: `http://xmlns.oracle.com/xdb/xdbconfig.xsd`. To configure or reconfigure Oracle XML DB, update the configuration file,

xdbconfig.xml. Its structure is described in the following sections. You need administrator privileges to access file xdbconfig.xml.

> **See Also:** "xdbconfig.xsd: XML Schema for Configuring Oracle XML DB" on page A-17 for a complete listing of the Oracle XML DB configuration XML schema

Element xdbconfig (Top-Level)

Element xdbconfig is the top-level element. Its structure is as follows:

```
<xdbconfig>
    <sysconfig> ... </sysconfig>
    <userconfig> ... </userconfig>
</xdbconfig>
```

Element sysconfig defines system-specific, built-in parameters. Element userconfig lets you store new custom parameters.

Element sysconfig (Child of xdbconfig)

Element sysconfig is a child of xdbconfig. Its structure is as follows:

```
<sysconfig>
    general parameters
    <protocolconfig> ... </protocolconfig>
</sysconfig>
```

Element sysconfig includes as content several general parameters that apply to all of Oracle XML DB, such as the maximum age of an access control list (ACL). Child element protocolconfig contains protocol-specific parameters.

> **Note:** Element case-sensitive, child of element sysconfig, has no effect on the case-sensitivity of XQuery or full-text search. Otherwise, it affects the behavior of all of Oracle XML DB.

Element userconfig (Child of xdbconfig)

Element userconfig is a child of xdbconfig. It contains any parameters that you may want to add.

Element protocolconfig (Child of sysconfig)

Element protocolconfig is a child of sysconfig. Its structure is as follows:

```
<protocolconfig>
  <common> ... </common>
  <ftpconfig> ... </ftpconfig>
  <httpconfig> ... </httpconfig>
</protocolconfig>
```

Under element common, Oracle Database stores parameters that apply to all protocols, such as MIME-type information. Parameters that are specific to protocols FTP and HTTP(S) are in elements ftpconfig and httpconfig, respectively.

> **See Also:** Chapter 28, "Repository Access Using Protocols", Table 28–1, Table 28–2, and Table 28–3, for a list of protocol configuration parameters

Element httpconfig (Child of protocolconfig)

Element `httpconfig` is a child of `protocolconfig`. Its structure is as follows:

```
<httpconfig>
  ...
  <webappconfig>
    ...
    <servletconfig>
      ...
      <servlet-list>
        <servlet> ... </servlet>
        ...
      </servlet-list>
    </servletconfig>
  </webappconfig>
  ...
  <plsql> ... </plsql>
</httpconfig>
```

Element `httpconfig` has the following child elements, in addition to others:

- `webappconfig` – used to configure Web-based applications. This includes Web application-specific parameters, such as icon name, display name for the application, and a list of servlets.

  Element `servletconfig` is a child of `webappconfig` that is used to define servlets. It has child element `servlet-list`, which has child element `servlet` (see "Element servlet (Descendant of httpconfig)" on page 35-6).

- `plsql`[1] – used to define global configuration parameters when configuring the *embedded PL/SQL gateway*. Each global parameter is defined with a child element of `plsql`. The element name is the same as the global parameter name. The element content is the same as the parameter value.

  The recommended way to configure the embedded PL/SQL gateway is to use the procedures in PL/SQL package `DBMS_EPG`, *not* to edit file `xdbconfig.xml`.

  See Also:

  - Chapter 28, "Repository Access Using Protocols", Table 28–1, Table 28–2, and Table 28–3, for a list of protocol configuration parameters
  - *Oracle Database Development Guide*, for complete information about configuring and using the embedded PL/SQL gateway
  - *Oracle Fusion Middleware Administrator's Guide for Oracle HTTP Server* for information about mod_plsql and conceptual information about using the PL/SQL gateway
  - *Oracle Database PL/SQL Packages and Types Reference*, for information about package `DBMS_EPG`

Element servlet (Descendant of httpconfig)

Element `servlet` is a descendent of element `httpconfig` – see "Element httpconfig (Child of protocolconfig)" on page 35-6. It is used to configure servlets, including Java servlets and embedded PL/SQL gateway servlets.

[1] There are two different `plsql` elements that are used to configure the embedded PL/SQL gateway. One, a child of `httpconfig`, defines *global parameters*. The other, a child of `servlet`, defines *DAD attributes*.

Note: The following servlets are preconfigured in file `xdbconfig.xml`. Do *not* delete them.

- `ORSServlet`
- `EMExpressServlet`

An optional element `plsql`, child of `servlet`[1], configures the embedded PL/SQL gateway servlet. However, the *recommended* way to configure the embedded gateway is to use the procedures in PL/SQL package `DBMS_EPG`, *not* to edit file `xdbconfig.xml`.

Element `plsql` has a child element for each embedded PL/SQL DAD attribute[2] that is needed to configure the embedded gateway. All such children are optional. The element name is the same as the DAD attribute name. The element content is the same as the DAD-attribute value.

See Also:

- Chapter 32, "How to Write Oracle XML DB Applications in Java" for information about configuring Java servlets
- *Oracle Database Development Guide*, for complete information on configuring and using the embedded PL/SQL gateway
- *Oracle Application Express Application Builder User's Guide*, for information about Oracle Application Express
- *Oracle Database PL/SQL Packages and Types Reference*, for information about package `DBMS_EPG`

Oracle XML DB Configuration File Example

The following is a sample Oracle XML DB configuration file:

Example 35–1 Oracle XML DB Configuration File

```
<xdbconfig xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xsi:schemaLocation="http://xmlns.oracle.com/xdb/xdbconfig.xsd
                                    http://xmlns.oracle.com/xdb/xdbconfig.xsd">
   <sysconfig>
      <acl-max-age>900</acl-max-age>
      <acl-cache-size>32</acl-cache-size>
      <invalid-pathname-chars>,</invalid-pathname-chars>
      <case-sensitive>true</case-sensitive>
      <call-timeout>300</call-timeout>
      <max-link-queue>65536</max-link-queue>
      <max-session-use>100</max-session-use>
      <persistent-sessions>false</persistent-sessions>
      <default-lock-timeout>3600</default-lock-timeout>
      <xdbcore-logfile-path>/sys/log/xdblog.xml</xdbcore-logfile-path>
      <xdbcore-log-level>0</xdbcore-log-level>
      <resource-view-cache-size>1048576</resource-view-cache-size>

      <protocolconfig>
          <common>
```

[2] DAD is an abbreviation for Database Access Descriptor. DAD attributes are parameters that define such a descriptor.

```
   <extension-mappings>
      <mime-mappings>
        <mime-mapping>
          <extension>au</extension>
          <mime-type>audio/basic</mime-type>
        </mime-mapping>
        <mime-mapping>
          <extension>avi</extension>
          <mime-type>video/x-msvideo</mime-type>
        </mime-mapping>
        <mime-mapping>
          <extension>bin</extension>
          <mime-type>application/octet-stream</mime-type>
        </mime-mapping>
      </mime-mappings>

      <lang-mappings>
        <lang-mapping>
          <extension>en</extension>
          <lang>english</lang>
        </lang-mapping>
      </lang-mappings>

      <charset-mappings>
      </charset-mappings>

      <encoding-mappings>
        <encoding-mapping>
          <extension>gzip</extension>
          <encoding>zip file</encoding>
        </encoding-mapping>
        <encoding-mapping>
          <extension>tar</extension>
          <encoding>tar file</encoding>
        </encoding-mapping>
      </encoding-mappings>
   </extension-mappings>

   <session-pool-size>50</session-pool-size>
   <session-timeout>6000</session-timeout>
</common>

<ftpconfig>
  <ftp-port>2100</ftp-port>
  <ftp-listener>local_listener</ftp-listener>
  <ftp-protocol>tcp</ftp-protocol>
  <logfile-path>/sys/log/ftplog.xml</logfile-path>
  <log-level>0</log-level>
  <session-timeout>6000</session-timeout>
  <buffer-size>8192</buffer-size>
</ftpconfig>

<httpconfig>
  <http-port>8080</http-port>
  <http-listener>local_listener</http-listener>
  <http-protocol>tcp</http-protocol>
  <max-http-headers>64</max-http-headers>
  <session-timeout>6000</session-timeout>
  <server-name>XDB HTTP Server</server-name>
  <max-header-size>16384</max-header-size>
```

```
            <max-request-body>2000000000</max-request-body>
            <logfile-path>/sys/log/httplog.xml</logfile-path>
            <log-level>0</log-level>
            <servlet-realm>Basic realm="XDB"</servlet-realm>
            <webappconfig>
              <welcome-file-list>
                <welcome-file>index.html</welcome-file>
                <welcome-file>index.htm</welcome-file>
              </welcome-file-list>
              <error-pages>
              </error-pages>
              <servletconfig>
                <servlet-mappings>
                  <servlet-mapping>
                    <servlet-pattern>/oradb/*</servlet-pattern>
                    <servlet-name>DBURIServlet</servlet-name>
                  </servlet-mapping>
                </servlet-mappings>

                <servlet-list>
                  <servlet>
                    <servlet-name>DBURIServlet</servlet-name>
                    <display-name>DBURI</display-name>
                    <servlet-language>C</servlet-language>
                    <description>Servlet for accessing DBURIs</description>
                    <security-role-ref>
                      <role-name>authenticatedUser</role-name>
                      <role-link>authenticatedUser</role-link>
                    </security-role-ref>
                  </servlet>
                </servlet-list>
              </servletconfig>
            </webappconfig>
          </httpconfig>
        </protocolconfig>
      <xdbcore-xobmem-bound>1024</xdbcore-xobmem-bound>
      <xdbcore-loadableunit-size>16</xdbcore-loadableunit-size>
    </sysconfig>
</xdbconfig>
```

Oracle XML DB Configuration API

You can access the Oracle XML DB configuration file, `xdbconfig.xml`, the same way you access any other XML schema-based resource in the hierarchy. It can be accessed using FTP, HTTP(S), WebDAV, Oracle Enterprise Manager, or any of the resource and Document Object Model (DOM) APIs for Java, PL/SQL, or C (OCI).

For convenience, you can use PL/SQL package `DBMS_XDB_CONFIG` package for configuration access. It exposes the following functions and procedures:

- `cfg_get` – Returns the configuration information for the current session.
- `cfg_refresh` – Refreshes the session configuration information using the current configuration file. Typical uses of `cfg_refresh` include the following:
  - You have modified the configuration and now want the session to pick up the latest version of the configuration information.
  - It has been a long running session, the configuration has been modified by a concurrent session, and you want the current session to pick up the latest version of the configuration information.

- `cfg_update` – Updates the configuration information, writing the configuration file. A `COMMIT` is performed.

Example 35–2 updates parameters `ftp-port` and `http-port` in the configuration file.

Example 35–2 Updating the Configuration File Using CFG_UPDATE and CFG_GET

```
DECLARE
  v_cfg XMLType;
BEGIN
  SELECT XMLQuery('declare default element namespace
                   "http://xmlns.oracle.com/xdb/xdbconfig.xsd";
                   copy $i := $cfg
                   modify for $j in $i/xdbconfig
                   return (replace value of node $j/descendant::ftp-port with
                             "2121",
                           replace value of node $j/descendant::http-port with
                             "19090")
                   return $i'
                  PASSING DBMS_XDB_CONFIG.cfg_get() AS "cfg"
                  RETURNING CONTENT)
    INTO v_cfg FROM DUAL;
  DBMS_XDB_CONFIG.cfg_update(v_cfg);
END;
/
```

If you have many parameters to update, then it can be easier to use FTP, HTTP(S), or Oracle Enterprise Manager to update the configuration.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Configuring Default Namespace to Schema Location Mappings

Oracle XML DB identifies schema-based `XMLType` instances by pre-parsing the input XML document. If the appropriate `xsi:schemaLocation` or `xsi:noNamespaceSchemaLocation` attribute is found, then the specified schema location URL is used to consult the registered schema. If the appropriate `xsi:` attribute is not found, the XML document is considered to be non-schema-based.

Oracle XML DB provides a mechanism to configure default schema location mappings. If the appropriate `xsi:` attribute is not specified in the XML document, the default schema location mappings is used. Element `schemaLocation-mappings` of the Oracle XML DB configuration XML schema, `xdbconfig.xsd`, can be used to specify the mapping between *(namespace, element)* pairs and the default schema location. If the *element* value is empty, the mapping applies to all global elements in the specified namespace. If the *namespace* value is empty, it corresponds to the null namespace.

The definition of the `schemaLocation-mappings` element is as follows:

```
<element name="schemaLocation-mappings"
         type="xdbc:schemaLocation-mapping-type" minOccurs="0"/>

<complexType name="schemaLocation-mapping-type"><sequence>
     <element name="schemaLocation-mapping"
              minOccurs="0" maxOccurs="unbounded">
     <complexType><sequence>
       <element name="namespace" type="string"/>
       <element name="element" type="string"/>
       <element name="schemaURL" type="string"/>
     </sequence></complexType>
     </element></sequence>
```

```
</complexType>
```

The schema location used depends on mappings in the Oracle XML DB configuration file for the namespace used and the root document element. For example, assume that the document does not have the appropriate `xsi:` attribute to indicate the schema location. Consider a document root element *R* in namespace *N*. The algorithm for identifying the default schema location is as follows:

1. If the Oracle XML DB configuration file has a mapping for *N* and *R*, the corresponding schema location is used.
2. If the configuration file has a mapping for *N*, but not *R*, the schema location for *N* is used.
3. If the document root *R* does not have any namespace, the schema location for *R* is used.

For example, suppose that your Oracle XML DB configuration file includes the following mapping:

```
<schemaLocation-mappings>
   <schemaLocation-mapping>
      <namespace>http://www.oracle.com/example</namespace>
      <element>root</element>
      <schemaURL>http://www.oracle.com/example/sch.xsd</schemaURL>
   </schemaLocation-mapping>
   <schemaLocation-mapping>
      <namespace>http://www.oracle.com/example2</namespace>
      <element></element>
      <schemaURL>http://www.oracle.com/example2/sch.xsd</schemaURL>
   </schemaLocation-mapping>
   <schemaLocation-mapping>
     <namespace></namespace>
     <element>specialRoot</element>
     <schemaURL>http://www.oracle.com/example3/sch.xsd</schemaURL>
   </schemaLocation-mapping>
</schemaLocation-mappings>
```

The following schema locations are used:

- Root element = `root`
  - Namespace = `http://www.oracle.com/example`
  - Schema URL = `http://www.oracle.com/example/sch.xsd`

  This mapping is used when the instance document specifies:

  ```
  <root xmlns="http://www.oracle.com/example">
  ```

- Root element = `null` (any global element in the namespace)
  - Namespace = `http://www.oracle.com/example2`
  - Schema URL = `http://www.oracle.com/example2/sch.xsd`

  This mapping is used when the instance document specifies:

  ```
  <root xmlns="http://www.oracle.example2">
  ```

- Root element = `specialRoot`
  - Namespace = `null` (i.e null namespace)
  - Schema URL = `http://www.oracle.com/example3/sch.xsd`

This mapping is used when the instance document specifies:

```
<specialRoot>
```

> **Note:** This functionality is available only on the server side, that is, when XML is parsed on the server. If XML is parsed on the client side, the appropriate `xsi:` attribute is still required.

Configuring XML File Extensions

Oracle XML DB Repository treats certain files as XML documents, based on their file extensions. When such files are inserted into the repository, Oracle XML DB pre-parses them to identify the schema location (or uses the default mapping if present) and inserts the document into the appropriate default table.

By default, the following extensions are considered as XML file extensions: **`xml`**, **`xsd`**, **`xsl`**, **`xlt`**. In addition, Oracle XML DB provides a mechanism for applications to specify other file extensions as XML file extensions. The **`xml-extensions`** element is defined in the configuration schema, `http://xmlns.oracle.com/xdb/xdbconfig.xsd`, as follows:

```
<element name="xml-extensions"
         type="xdbc:xml-extension-type" minOccurs="0"/>

<complexType name="xml-extension-type"><sequence>
     <element name="extension" type="xdbc:exttype"
              minOccurs="0" maxOccurs="unbounded">
     </element></sequence>
 </complexType>
```

For example, the following fragment from the Oracle XML DB configuration file, `xdbconfig.xml`, specifies that files with extensions `vsd`, `vml`, and `svgl` should be treated as XML files:

```
<xml-extensions>
  <extension>vsd</extension>
  <extension>vml</extension>
  <extension>svgl</extension>
</xml-extensions>
```

Oracle XML DB and Database Consolidation

A multitenant container database (CDB) consists of zero or more pluggable databases (PDBs), a root, and a seed PDB (a template for creating PDBs). A given PDB can be associated with only one CDB at a time.

A PDB appears to users and applications as a separate database. Your applications always interact with a single PDB at a time. Queries and dictionary views are local to a PDB. Each PDB has its own Oracle XML DB Repository, and its own Oracle XML DB configuration file, `xdbconfig.xml`.

The root of a CDB (`CDB$ROOT`) contains no user data. It does, however, have its own configuration file, `xdbconfig.xml`.

The root configuration file for a CDB has only certain parameters, and those parameters are used only from the root configuration file. If any of those parameters are also present in a configuration file of a PDB that is part of a CDB, they are ignored in favor of the corresponding parameters in the root configuration file.

These are the configuration parameters that are used from the root (and ignored from any PDBs):

- acl-cache-size
- acl-max-age
- resource-view-cache-size
- xdbcore-loadableunit-size
- xdbcore-xobmem-bound

Parameters xdbcore-loadableunit-size and xdbcore-xobmem-bound are process-specific. The others are SGA configuration parameters.

Database schema (user account) XDB is a common user, which means that it can connect to, and perform operations within, both the root and any PDBs.

Note: Oracle recommends that you never unlock database schema XDB, under any circumstances.

See Also:

- *Oracle Database Administrator's Guide* and *Oracle Database Concepts* for information about database consolidation and PDBs
- "Performance Tuning of Oracle XML DB Repository Operations" on page 24-19 for information about configuration parameters resource-view-cache-size, xdbcore-loadableunit-size, and xdbcore-xobmem-bound
- "Considerations for Loading and Retrieving Large Documents with Collections" on page 18-53 for information about configuration parameters xdbcore-loadableunit-size and xdbcore-xobmem-bound
- "ACL Caching" on page 27-16 for information about configuration parameter acl-max-age

Package DBMS_XDB_ADMIN

Table 35–1 describes DBMS_XDB_ADMIN PL/SQL procedures for managing and configuring Oracle XML DB and Oracle XML DB Repository.

Table 35–1 DBMS_XDB_ADMIN Management Procedures

Function/Procedure	Description
moveXDB_tablespace	Move database schema (user account) XDB to the specified tablespace.
rebuildHierarchicalIndex	Rebuild the hierarchical repository index. This can be needed from time to time, in particular after invoking moveXDB_tablespace.

Note: Prior to Oracle Database 11g Release 2 (11.2.0.3), these procedures belonged to PL/SQL package DBMS_XDB. These two procedures in package DBMS_XDB are *deprecated* as of release 11.2.0.3.

Note: The tablespace containing Oracle XML DB Repository *must not* be read-only, because that would adversely affect XML operations.

By default, Oracle XML DB Repository resides in tablespace `SYSAUX`, which is used for other things as well. Oracle recommends instead that you create a dedicated tablespace for use only by the repository.

Use procedure `DBMS_XDB_ADMIN.moveXDB_tablespace` to move database schema `XDB` to that tablespace dedicated to the repository. Ensure that the tablespace is not read-only.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

36

How to Load XML Data

This chapter describes how to load XML data into Oracle XML DB, with a focus on SQL*Loader.

This chapter contains these topics:

- Overview of Loading XMLType Data Into Oracle Database
- Load XMLType Data Using SQL*Loader
- Loading Large XML Documents Using SQL*Loader

> **See Also:** Chapter 3, "Overview of How To Use Oracle XML DB"

Overview of Loading XMLType Data Into Oracle Database

Starting with Oracle9*i* release 1 (9.0.1), the Export-Import utility and SQL*Loader support `XMLType` as a column type. Starting with Oracle Database 10*g*, SQL*Loader also supports loading `XMLType` tables. You can load `XMLType` data with SQL*Loader using either the conventional method or the direct-path method, regardless of how it is stored (object-relational or binary XML storage).

Note: For *object-relational storage* of XML data, if the data involves *inheritance* (extension or restriction) of XML Schema types, then SQL*Loader does *not* support direct-path loading.

That is, if an XML schema contains a `complexType` element that extends or restricts another `complexType` element (the base type), then this results in some SQL types being defined in terms of other SQL types. In this case, direct-path loading is not supported for object-relational storage.

> **See Also:** Chapter 37, "Export and Import of Oracle XML DB Data" and *Oracle Database Utilities*

Oracle XML DB Repository information is *not* exported when user data is exported. Neither the resources nor any information are exported.

Load XMLType Data Using SQL*Loader

XML columns are columns declared to be of type `XMLType`.

SQL*Loader treats XMLType columns and tables like object-relational columns and tables. All methods described in the following sections for loading LOB data from the primary datafile or from a LOBFILE value apply also to loading XMLType columns and tables when the XMLType data is stored as a LOB.

See Also: *Oracle Database Utilities*

Note: You cannot specify a SQL string for LOB fields. This is true even if you specify LOBFILE_spec.

XMLType data can be present in a control file or in a LOB file. In the former case, the LOB file name is present in the control file.

Because XMLType data can be quite large, SQL*Loader can load LOB data from either a primary datafile (in line with the rest of the data) or from LOB files, independent of how the data is stored (the underlying storage can, for example, still be object-relational).

Load XMLType Data in LOBs Using SQL*Loader

To load internal LOBs, Binary Large Objects (BLOBs), Character Large Objects (CLOBs), and National Character Large Object (NCLOBs), or XMLType columns and tables from a primary datafile, use the following standard SQL*Loader formats:

- Predetermined size fields
- Delimited fields
- Length-value pair fields

These formats are described in the following sections and in more detail in *Oracle Database Utilities.*

Loading LOB Data in Predetermined Size Fields

This is a very fast and conceptually simple format to load LOBs.

Note: Because the LOBs you are loading might not be of equal size, you can use whitespace to pad the LOB data to make the LOBs all of equal length within a particular data field.

Load LOB Data in Delimited Fields

This format handles LOBs of different sizes within the same column (datafile field) without problem. However, this added flexibility can affect performance, because SQL*Loader must scan through the data, looking for the delimiter string.

As with single-character delimiters, when you specify string delimiters, you should consider the character set of the datafile. When the character set of the datafile is different than that of the control file, you can specify the delimiters in hexadecimal (that is, hexadecimal string). If the delimiters are specified in hexadecimal notation, then the specification must consist of characters that are valid in the character set of the input datafile. In contrast, if hexadecimal specification is not used, then the delimiter specification is considered to be in the client (that is, the control file) character set. In this case, the delimiter is converted into the datafile character set before SQL*Loader searches for the delimiter in the datafile.

Load XML Columns Containing LOB Data from LOBFILEs

LOB data can be lengthy enough so that it makes sense to load it from a LOBFILE instead of from a primary datafile. In LOBFILEs, LOB data instances are still considered to be in fields (predetermined size, delimited, length-value), but these fields are not organized into records (the concept of a record does not exist within LOBFILEs). Therefore, the processing overhead of dealing with records is avoided. This type of organization of data is ideal for LOB loading.

There is no requirement that a LOB from a LOBFILE fit in memory. SQL*Loader reads LOBFILEs in 64 KB chunks.

In LOBFILEs the data can be in any of the following types of fields, any of which can be used to load XML columns:

- A single LOB field into which the entire contents of a file can be read
- Predetermined size fields (fixed-length fields)
- Delimited fields (that is, `TERMINATED BY` or `ENCLOSED BY`)

  The clause `PRESERVE BLANKS` is not applicable to fields read from a LOBFILE.
- Length-value pair fields (variable-length fields).

  To load data from this type of field, use the `VARRAY`, `VARCHAR`, or `VARCHAR2` SQL*Loader data types.

Specify LOBFILEs

You can specify LOBFILEs either statically (you specify the name of the file) or dynamically (you use a FILLER field as the source of the filename). In either case, when the EOF of a LOBFILE is reached, the file is closed and additional attempts to read data from that file produce results equivalent to reading data from an empty field.

You should not specify the same LOBFILE as the source of two different fields. If you do so, then typically, the two fields read the data independently.

Load XMLType Data Directly from a Control File Using SQL*Loader

`XMLType` data can be loaded directly from a control file. SQL*Loader treats `XMLType` data like any scalar type. For example, consider a table containing a `NUMBER` column followed by an `XMLType` column that is stored object-relationally. The control file used for this table can contain the value of the `NUMBER` column followed by the value of the `XMLType` instance.

SQL*Loader accommodates `XMLType` instances that are very large. You also have the option to load such data from a LOB file.

Loading Large XML Documents Using SQL*Loader

You can use SQL*Loader to load large amounts of XML data into Oracle Database. Follow these steps:

1. List in a data file, say `filelist.dat`, the locations of the XML documents to be loaded.
2. Create a control file, say `load_data.ctl`, with commands that process the files listed in the data file.
3. Invoke the SQL*Loader shell command, `sqlldr`, passing it the name of the control file.

This is illustrated in Example 36–2, Example 36–1, and Example 36–3. File `filelist.dat` lists XML files that contain purchase orders for the year 2002.

Example 36–1 Data File filelist.dat: List of XML Files to Load

```
2002/Jan/AMCEWEN-20021009123335370PDT.xm
2002/Jan/AWALSH-2002100912333570PDT.xml
2002/Jan/CJOHNSON-20021009123335170PDT.xml
2002/Jan/LSMITH-20021009123335500PDT.xml
2002/Jan/PTUCKER-20021009123335430PDT.xml
2002/Jan/SBELL-20021009123335280PDT.xml
2002/Jan/SKING-20021009123335560PDT.xml
2002/Jan/SMCCAIN-20021009123335470PDT.xml
2002/Jan/TFOX-20021009123335520PDT.xml
2002/Jan/VJONES-20021009123335350PDT.xml
2002/Jan/WSMITH-20021009123335450PDT.xml
2002/Feb/AMCEWEN-20021009123335600PDT.xml
2002/Feb/AMCEWEN-20021009123335701PDT.xml
2002/Feb/DAUSTIN-20021009123335811PDT.xml
2002/Feb/EABEL-20021009123335791PDT.xml
2002/Feb/PTUCKER-20021009123335721PDT.xml
2002/Feb/PTUCKER-20021009123335821PDT.xml
2002/Feb/SBELL-20021009123335771PDT.xml
2002/Feb/SMCCAIN-20021009123335681PDT.xml
2002/Feb/WSMITH-20021009123335650PDT.xml
2002/Feb/WSMITH-20021009123335741PDT.xml
2002/Feb/WSMITH-20021009123335751PDT.xml
...
```

Example 36–2 Control File load_datra.ctl, for Loading Purchase-Order XML Documents

```
load data
infile 'filelist.dat'
append
into table PURCHASEORDER
xmltype(XMLDATA)
(
 filename filler char(120),
 XMLDATA  lobfile(filename) terminated by eof
)
```

Example 36–3 Loading XML Data Using Shell Command sqlldr

```
sqlldr load_data.ctl
```

For direct-path loading, use this instead:

```
sqlldr load_data.ctl direct=y
```

If your application uses indexes or constraints then processing of these can impact loading performance. You can temporarily disable this processing using PL/SQL subprograms `disableIndexesAndConstraints` and `enableIndexesAndConstraints` in package `DBMS_XMLSTORAGE_MANAGE`.

See Also:

- Chapter 3, "Overview of How To Use Oracle XML DB", "Loading Large XML Files Using SQL*Loader" on page 3-12
- *Oracle Database Utilities* for information about shell command `sqlldr`
- *Oracle Database PL/SQL Packages and Types Reference* for information about `DBMS_XMLSTORAGE_MANAGE` subprograms `disableIndexesAndConstraints` and `enableIndexesAndConstraints`

37

Export and Import of Oracle XML DB Data

This chapter describes how you can use Oracle Data Pump to export and import `XMLType` tables for use with Oracle XML DB.

> **Note:** You can use the older export and import utilities `exp` and `imp` to migrate data to database releases that are prior to Oracle Database 11*g*. However, these older utilities do not support using `XMLType` data that is stored as binary XML.

This chapter discusses the following topics:

- Overview of Exporting and Importing XMLType Tables
- Export/Import Limitations for Oracle XML DB Repository
- Export/Import Syntax and Examples

Overview of Exporting and Importing XMLType Tables

Oracle Data Pump enables high-speed movement of data and metadata from one database to another. There are two modes for using Oracle Data Pump: transportable tablespaces mode and non-transportable tablespaces mode. For the transportable tablespaces mode there is this restriction regarding `XMLType` data: you cannot change the `XMLType` storage model.

As with other database objects, XML data is exported in the character set of the exporting server. During import, the data is converted to the character set of the importing server.

Oracle Data Pump has two command-line clients, `expdp` and `impdp`, that invoke Data Pump Export utility and Data Pump Import utility, respectively. The `expdp` and `impdp` clients use procedures provided in PL/SQL package `DBMS_DATAPUMP` to execute export and import commands, passing the parameters entered at the command-line. These parameters enable the exporting and importing of data and metadata for a complete database or subsets of a database.

The Data Pump Export and Import utilities (invoked with commands `expdp` and `impdp`, respectively) have a similar look and feel to the original Export (`exp`) and Import (`imp`) utilities, but they are completely separate.

Data Pump Export utility (invoked with `expdp`) unloads data and metadata into a set of operating system files called a *dump file set*. The dump file set can be imported only by the Data Pump Import utility (invoked using `impdp`).

Oracle XML DB supports export and import of `XMLType` tables and columns that store XML data, whether it is XML schema-based or not.

If a table is XML schema-based, then it depends on the XML schema used to define its data. This XML schema can also have dependencies on SQL object types that are used to store the data, in the case of object-relational storage. Therefore, exporting a user who has XML schema-based `XMLType` tables also exports the following:

- SQL objects types (if object-relational storage was used)
- XML schemas
- XML tables

You can export and import this data regardless of the `XMLType` storage format (object-relational or binary XML). However, Oracle Data Pump exports and imports XML data as text or binary XML data only. The underlying tables and columns used for object-relational storage of `XMLType` are thus not exported. Instead, they are converted to binary form and then exported as self-describing binary XML data.

Note: Oracle Data Pump for Oracle Database 11*g* Release 1 (11.1) does not support the export of XML schemas, XML schema-based `XMLType` columns, or binary XML data to database releases prior to 11.1.

Regardless of the `XMLType` storage model, the format of the dump file is either text or self-describing binary XML with a token map preamble. By default, self-describing binary XML is used.

How Oracle Data Pump stores this data in the dump file depends on the value of the export parameter, `data_options` (the only valid value for this parameter is `xml_clobs`.) If you specify this value on the export command line then all `XMLType` data is stored in text format in the dump file. Otherwise, the dump file uses binary XML.

Note: The value `xml_clobs` for export parameter `data_options` is *deprecated* starting with Oracle Database 12*c* Release 1 (12.1.0.1).

Since `XMLType` data is exported and imported as XML data, the source and target databases can use different `XMLType` storage models for that data. You can export data from a database that stores `XMLType` data one way and import it into a database that stores `XMLType` data a different way.

Note: Do not use option `table_exists_action=append` to import more than once from the same dump file into an `XMLType` table, regardless of the `XMLType` storage model used. Doing so raises a unique-constraint violation error because rows in `XMLType` tables are always exported and imported using a unique object identifier.

See *Oracle Database Utilities* for information about `table_exists_action`.

Export/Import Limitations for Oracle XML DB Repository

You can export and import the XMLType tables that store the XML data for Oracle XML DB Repository resources that are based on a registered XML schema.

However, only the XML data is exported. The repository structure, that is, the relationships in the foldering hierarchy, are lost during export. The row-level security (RLS) policies and path-index triggers are not exported for hierarchy-enabled tables. When these tables are imported, they are not hierarchy-enabled.

Export/Import Syntax and Examples

Export and import using Oracle Data Pump is described in *Oracle Database Utilities.* This section includes additional guidelines and examples for using commands expdp and impdp with XMLType data.

The examples presented here use the command-line commands expdp and impdp. After submitting such a command with a user name and command parameters, you are prompted for a password. The examples here do not show this prompting.

Performing a Table-Mode Export /Import

An XMLType table has a dependency on the XML schema that was used to define it. Similarly, the XML schema has dependencies on the SQL object types created or specified for it. Importing an XMLType table requires the existence of the XML schema and the SQL object types. When a TABLE mode export is used, only the table related metadata and data are exported. To be able to import this data successfully, the user needs to ensure that both the XML schema and object types have been created.

The examples here assume that you are using a database with the following features:

- A database with schema user23
- A table user23.tab41 with an XMLType column stored as binary XML
- A directory object dpump_dir, for which READ and WRITE privileges have been granted to the user running expdp or impdp

Example 37–1 shows a table-mode export, specified using the TABLES parameter. It exports table tab41 to dump file tab41.dmp.

Example 37–1 Exporting XMLType Data in TABLE Mode

```
expdp system directory=dpump_dir dumpfile=tab41.dmp tables=user23.tab41
```

> **Note:** In table mode, if you do not specify a schema prefix in the expdp command then the schema of the exporter is used by default.

Example 37–2 shows a table-mode import. It imports table tab41 from dump file tab41.dmp.

Example 37–2 Importing XMLType Data in TABLE Mode

```
impdp system tables=user23.tab41 directory=dpump_dir dumpfile=tab41.dmp table_exists_action=append
```

If a table named tab41 already exists at the time of the import then specifying table_exists_action = append causes rows to be appended to that table. Whenever you use

parameter value append the data is loaded into new space; existing space is never reused. For this reason you might need to compress your data after the load operation.

> **See Also:** *Oracle Database Utilities*, for more information about Oracle Data Pump and its command-line clients, expdp and impdp

Performing a Schema-Mode Export/Import

When performing a Schema mode export, if you have role EXP_FULL_DATABASE, then you can export a database schema, the database schema definition, and the system grants and privileges of that database schema.

The example here assumes that you are using a database with the following features:

- User x4a has created a table po2.
- User x4a has a registered XML schema, ipo, which created two ordered collection tables item_oct2 and sitem_nt2.

User x4a creates table po2 as shown in Example 37–3.

Example 37–3 Creating Table po2

```
CREATE TABLE po2 (po XMLType)
  XMLTYPE COLUMN po
  XMLSCHEMA "ipo.xsd"
  ELEMENT "purchaseOrder"
  VARRAY po.XMLDATA."items"."item"
    STORE AS TABLE item_oct2 ((PRIMARY KEY(NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
      NESTED TABLE po.XMLDATA."shippedItems"."item" STORE AS sitem_nt2;
```

Table po2 is then populated and exported, as shown in Example 37–4.

Example 37–4 Exporting XMLType Data in SCHEMA Mode

```
expdp x4a directory=tkxm_xmldir dumpfile=x4a.dmp
```

Example 37–4 exports all of the following:

- All data types that were generated during registration of XML schema ipo.
- XML schema ipo.
- Table po2 and the ordered collection tables item_oct2 and sitem_nt2, which were generated during registration of XML schema ipo.
- All data in all of those tables.

Example 37–5 Importing XMLType Data in SCHEMA Mode

```
impdp x4a directory=tkxm_xmldir dumpfile=x4a.dmp
```

Example 37–5 imports all of the data in x4a.dmp to another database, in which the user x4a already exists.

Example 37–6 does the same thing as Example 37–5, but it also remaps the database schema from user x4a to user quine.

Example 37–6 Importing XMLType Data in SCHEMA Mode, Remapping Schema

```
impdp x4a directory=tkxm_xmldir dumpfile=x4a.dmp remap_schema=x4a:quine
```

Example 37–6 imports all of the data in `x4a.dmp` (exported from the database schema of user `x4a`) into database schema `quine`. To remap the database schema, user `x4a` must have been granted role `IMP_FULL_DATABASE` on the local database and role `EXP_FULL_DATABASE` on the source database. `REMAP_SCHEMA` loads all of the objects from the source schema into the target schema.

Note: If you import an XML schema into the same database that it was exported from, and if that XML schema is still registered with Oracle XML DB at the time of importing, do not use `remap_schema` unless you also specify `impdp` parameter `transform=oid:n`. See *Oracle Database Utilities* for information about parameter `transform`.

38

XML Data Exchange Using Oracle Streams AQ

Oracle Streams Advanced Queuing (AQ) provides database-integrated message-queuing:

- It enables and manages asynchronous communication of two or more applications, using messages
- It supports point-to-point and publish/subscribe communication models

Integration of message queuing with Oracle Database brings the integrity, reliability, recoverability, scalability, performance, and security features of Oracle Database to message queuing. It also facilitates the extraction of intelligence from message flows.

This chapter describes how XML data can be exchanged using AQ. It contains these topics:

AQ and XML Complement Each Other

XML is a standard format for business communications. It is used not only for data communicated between business applications but also to represent business logic.

In Oracle Database, AQ supports native XML messages. It lets AQ operations be defined using the XML-based Internet-Data-Access-Presentation (iDAP) format. iDAP is an extensible message invocation protocol. It is built on Internet standards, using HTTP(S) and e-mail protocols as the transport mechanism. XML is the data representation language for iDAP.

AQ and XML Message Payloads

Figure 38–1 shows an Oracle database using AQ to communicate with three applications. The message payload is XML data. The general tasks performed by AQ in this scenario are:

- Message flow using subscription rules
- Message management

- Extraction of business intelligence from messages
- Message transformation

XML messages are passed asynchronously among applications using AQ.

- Intra-business. Typical examples include sales order fulfillment and supply-chain management.
- Inter-business. Multiple integration hubs can communicate over the Internet. Examples include travel reservations, coordination between manufacturers and suppliers, transfer of funds between banks, and insurance claims settlements.

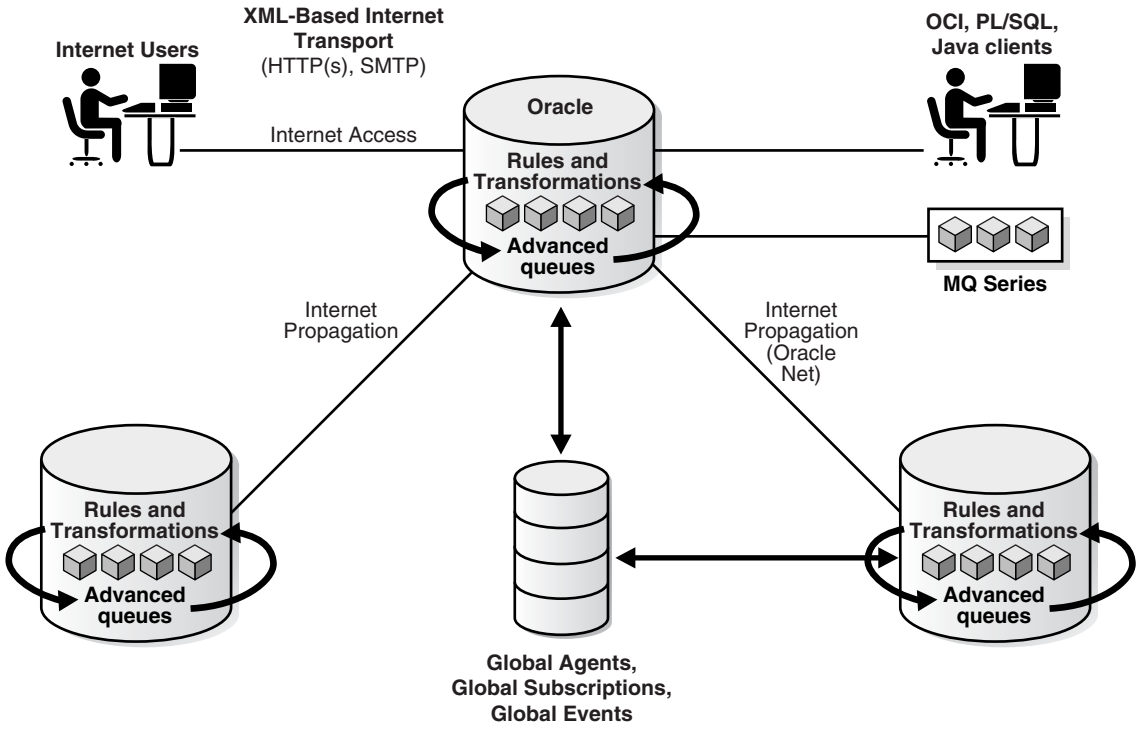
  Oracle uses this approach in its enterprise application integration products. XML messages are sent from applications to an Oracle AQ hub. The hub serves as a message server for any application that wants the message. Through this hub-and-spoke architecture, XML messages can be communicated asynchronously to multiple loosely coupled applications.

Figure 38–1 shows XML payload messages transported using AQ in the following ways:

- A Web-based application uses an AQ operation over an HTTP(S) connection using iDAP
- An application uses AQ to propagate an XML message over a Net* connection
- An application uses AQ to propagate an Internet or XML message directly to the database using HTTP(S) or SMTP

Figure 38–1 also shows that AQ clients can access data using OCI, Java, or PL/SQL.

Figure 38–1 Oracle Streams Advanced Queuing and XML Message Payloads



Advantages of Using AQ

AQ provides flexibility in configuring communication between different applications. It makes an integrated solution easy to manage, easy to configure, and easy to modify, to meet changing business needs. It enables multiple applications to cooperate, coordinate, and synchronize, to carry out complex business transactions.

Message management provided by AQ manages the flow of messages between different applications. AQ can also retain messages for auditing and tracking purposes, and for extracting business intelligence.

AQ provides SQL views to access messages. You can use these views to analyze trends.

Oracle Streams and AQ

Oracle Streams (Streams) enables you to share data and events in a stream. The stream can propagate this information within a database or from one database to another. The stream routes specified information to specified destinations. This provides greater functionality and flexibility than traditional solutions for capturing and managing events, and sharing the events with other databases and applications.

Streams enables you to break the cycle of trading off one solution for another. It enable you to build and operate distributed enterprises and applications, data warehouses, and high availability solutions. You can use all the capabilities of Oracle Streams at the same time.

You can use Streams to:

- *Capture changes at a database.* You can configure a background capture process to capture changes made to tables, database schemas, or the entire database. A capture process captures changes from the redo log and formats each captured change into a logical change record (LCR). The database where changes are generated in the redo log is called the source database.
- *Enqueue events into a queue.* Two types of events may be staged in a Streams queue: LCRs and user messages. A capture process enqueues LCR events into a queue that you specify. The queue can then share the LCR events within the same database or with other databases. You can also enqueue user events explicitly with a user application. These explicitly enqueued events can be LCRs or user messages.
- *Propagate events from one queue to another.* These queues may be in the same database or in different databases.
- *Dequeue events.* A background apply process can dequeue events. You can also dequeue events explicitly with a user application.
- *Apply events at a database.* You can configure an apply process to apply all of the events in a queue or only the events that you specify. You can also configure an apply process to call your own PL/SQL subprograms to process events.

  The database where LCR events are applied and other types of events are processed is called the destination database. In some configurations, the source database and the destination database may be the same.

Streams Message Queuing

Streams lets user applications:

- Enqueue messages of different types

- Propagate messages are ready for consumption
- Dequeue messages at the destination database

Streams introduces a new type of queue that stages messages of type `SYS.AnyData`. Messages of almost any type can be wrapped in a `SYS.AnyData` wrapper and staged in `SYS.AnyData` queues. Streams interoperates with Advanced Queuing (AQ), which supports all the standard features of message queuing systems, including multiconsumer queues, publishing and subscribing, content-based routing, internet propagation, transformations, and gateways to other messaging subsystems.

> **See Also:** *Oracle Streams Concepts and Administration*, and its Appendix A, "XML Schema for LCRs".

XMLType Attributes in Object Types

You can create queues that use Oracle object types containing `XMLType` attributes. These queues can be used to transmit and store messages that are XML documents. Using `XMLType`, you can do the following:

- Store any type of message in a queue
- Store documents internally as `CLOB` instances
- Store more than one type of payload in a queue
- Query `XMLType` columns using SQL/XML functions such as `XMLExists`
- Specify the operators in subscriber rules or dequeue selectors

Internet Data Access Presentation (iDAP): SOAP for AQ

You can access Oracle Streams Advanced Queuing (AQ) over the Internet using Simple Object Access Protocol (SOAP). Internet Data Access Presentation (iDAP) is the SOAP specification for AQ operations. iDAP defines XML message structure for the body of the SOAP request. An iDAP-structured message is transmitted over the Internet using transport protocols such as HTTP(S) and SMTP.

iDAP uses the `text/xml` content type to specify the body of the SOAP request. XML provides the presentation for iDAP request and response messages as follows:

- All request and response tags are scoped in the SOAP namespace.
- AQ operations are scoped in the iDAP namespace.
- The sender includes namespaces in iDAP elements and attributes in the SOAP body.
- The receiver processes iDAP messages that have correct namespaces. For the requests with incorrect namespaces, the receiver returns an invalid request error.
- The SOAP namespace has this value: `http://schemas.xmlsoap.org/soap/envelope/`
- The iDAP namespace has this value: `http://ns.oracle.com/AQ/schemas/access`

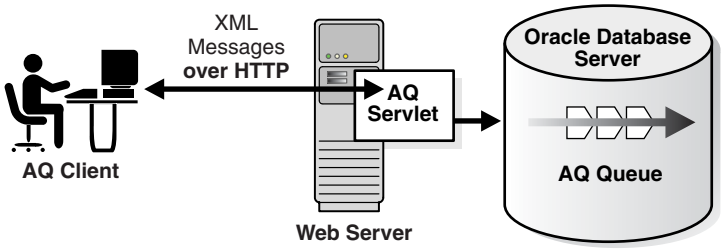
> **See Also:** *Oracle Database Advanced Queuing User's Guide*

iDAP Architecture

Figure 38–2 shows the following components needed to send HTTP(S) messages:

- A client program that sends XML messages, conforming to iDAP format, to the AQ Servlet. This can be any HTTP client, such as Web browsers.
- The Web server or `ServletRunner` which hosts the AQ servlet that can interpret the incoming XML messages, for example, Apache/Jserv or Tomcat.
- Oracle Server/Database. Oracle Streams AQ servlet connects to Oracle Database to perform operations on your queues.

Figure 38–2 iDAP Architecture for Performing AQ Operations Using HTTP(S)



XMLType Queue Payloads

You can create queues with payloads that contain `XMLType` attributes. These can be used for transmitting and storing messages that contain XML documents. By defining Oracle objects with `XMLType` attributes, you can do the following:

- Store more than one type of XML document in the same queue. The documents are stored internally as `CLOB` instances.
- Selectively dequeue messages with `XMLType` attributes using SQL/XML functions such as `XMLExists` and `XMLQuery`.
- Define transformations to convert Oracle objects to `XMLType`.
- Define rule-based subscribers that query message content using SQL/XML functions such as `XMLExists` and `XMLQuery`.

In the BooksOnline application, assume that the Overseas Shipping site represents an order using `SYS.XMLType`. The Order Entry site represents an order as an Oracle object, `ORDER_TYP`.

Example 38–1 creates the queue table and queue for Overseas Shipping.

Example 38–1 Creating a Queue Table and Queue

```
BEGIN
   DBMS_AQADM.create_queue_table(
     queue_table        => 'OS_orders_pr_mqtab',
     comment            => 'Overseas Shipping MultiConsumer Orders queue table',
     multiple_consumers => TRUE,
     queue_payload_type => 'SYS.XMLtype',
     compatible         => '8.1');
END;
/

BEGIN
   DBMS_AQADM.create_queue(queue_name   => 'OS_bookedorders_que',
                           queue_table  => 'OS_orders_pr_mqtab');
END;
/
```

Because the representation of orders at the overseas shipping site is different from the representation of orders at the order-entry site, messages need to be transformed before sending them from the order-entry site to the overseas shipping site. Example 38–2 creates the transformation, and Example 38–3 applies it.

Example 38–2 Creating a Transformation to Convert Message Data to XML

```
CREATE OR REPLACE FUNCTION convert_to_order_xml(input_order ORDER_TYP)
  RETURN XMLType AS
    new_order XMLType;
BEGIN
  SELECT XMLElement("Row", input_order) INTO new_order FROM DUAL;
  RETURN new_order;
END convert_to_order_xml;
/

BEGIN
  SYS.DBMS_TRANSFORM.create_transformation(
    schema =>         'OE',
    name   =>         'OE2XML',
    from_schema =>    'OE',
    from_type =>      'ORDER_TYP',
    to_schema =>      'SYS',
    to_type =>        'XMLTYPE',
    transformation => 'convert_to_order_xml(source.user_data)');
END;
/
```

Example 38–3 Applying a Transformation before Sending Messages Overseas

```
-- Add a rule-based subscriber for overseas shipping to the booked-orders
-- queues with transformation.
DECLARE
   subscriber SYS.AQ$_AGENT;
BEGIN
   subscriber := SYS.AQ$_AGENT('Overseas_Shipping',
                               'OS.OS_bookedorders_que',
                               NULL);
   DBMS_AQADM.add_subscriber(
     queue_name     => 'OS_bookedorders_que',
     subscriber     => subscriber,
     rule           => 'XMLSerialize(CONTENT XMLQuery(''//orderregion''' ||
                       'PASSING tab.user_data RETURNING CONTENT)' ||
                       ' AS VARCHAR2(1000)) = ''INTERNATIONAL''',
     transformation => 'OE.OE2XML');
END;
/
```

For more information about defining transformations that convert the type used by the order entry application to the type used by Overseas Shipping, see *Oracle Database Advanced Queuing User's Guide*.

Example 38–4 shows how an application that processes orders for customers in another country, in this case Canada, can dequeue messages.

Example 38–4 XMLType and AQ: Dequeuing Messages

```
-- Create procedure to enqueue into single-consumer queues.
CREATE OR REPLACE PROCEDURE get_canada_orders AS
   deq_msgid             RAW(16);
```

```
   dopt                 DBMS_AQ.dequeue_options_t;
   mprop                DBMS_AQ.message_properties_t;
   deq_order_data       SYS.XMLType;
   deq_order_data_text  CLOB;
   no_messages          EXCEPTION;
   PRAGMA EXCEPTION_INIT (no_messages, -25228);
   new_orders           BOOLEAN := TRUE;
BEGIN
   dopt.wait := 1;
   -- Specify dequeue condition to select orders for Canada.
   dopt.deq_condition := 'XMLSerialize(CONTENT ' ||
                         'XMLQuery(''/ORDER_TYP/CUSTOMER/COUNTRY/text()''' ||
                         ' PASSING tab.user_data RETURNING CONTENT)' ||
                         ' AS VARCHAR2(1000))=''CANADA''';
   dopt.consumer_name := 'Overseas_Shipping';
   WHILE (new_orders) LOOP
     BEGIN
       DBMS_AQ.dequeue(queue_name         => 'OS.OS_bookedorders_que',
                       dequeue_options    => dopt,
                       message_properties => mprop,
                       payload            => deq_order_data,
                       msgid              => deq_msgid);
       COMMIT;
       SELECT XMLSerialize(DOCUMENT deq_order_data AS CLOB)
         INTO deq_order_data_text FROM DUAL;
       DBMS_OUTPUT.put_line('Order for Canada - Order: ' || deq_order_data_text);
     EXCEPTION
       WHEN no_messages THEN
         DBMS_OUTPUT.put_line (' ---- NO MORE ORDERS  ---- ');
         new_orders := FALSE;
     END;
   END LOOP;
END;
/
```

Guidelines for Using XML and Oracle Streams Advanced Queuing

This section describes guidelines for using XML and Oracle Streams Advanced Queuing.

Store Oracle Streams AQ XML Messages with Many PDFs as One Record?

You can exchange XML documents between businesses using Oracle Streams Advanced Queuing, where each message received or sent includes an XML header, XML attachment (XML data stream), DTDs, and PDF files, and store the data in a database table, such as a `queuetable`. You can enqueue the messages into Oracle queue tables as one record or piece. Or you can enqueue the messages as multiple records, such as one record for XML data streams as `CLOB` type, one record for PDF files as `RAW` type, and so on. You can also then dequeue the messages.

You can achieve this in the following ways:

- By defining an object type with (`CLOB`, `RAW`,...) attributes, and storing it as a single message.
- By using the AQ message grouping feature and storing it in multiple messages. Here the message properties are associated with a group. To use the message grouping feature, all messages must be the same payload type.

To specify the payload, first create an object type, for example:

```
CREATE TYPE mypayload_type as OBJECT (xmlDataStream CLOB, dtd CLOB, pdf BLOB);
```

then store it as a single message.

Add New Recipients After Messages Are Enqueued

You can use the queue table to support message assignments. For example, when other businesses send messages to a specific company, they do not know who should be assigned to process the messages, but they know the messages are for Human Resources (HR) for example. Hence all messages go to the HR supervisor. At this point, the message is enqueued in the queue table. The HR supervisor is the only recipient of this message, and the entire HR staff have been pre-defined as subscribers for this queue.

You cannot change the recipient list after the message is enqueued. If you do not specify a recipient list then subscribers can subscribe to the queue and dequeue the message. Here, new recipients must be subscribers to the queue. Otherwise, you must dequeue the message and enqueue it again with new recipients.

Enqueue and Dequeue XML Messages?

Oracle Streams AQ supports enqueuing and dequeuing objects. These objects can have an attribute of type `XMLType` that contains an XML document, in addition to metadata attributes. Refer to *Oracle Database Advanced Queuing User's Guide* for specific details and more examples.

Parse Messages with XML Content from Oracle Streams AQ Queues

You can parse messages with XML content from an Oracle Streams AQ queue and then update tables and fields in an ODS (Operational Data Store).

You can use Oracle XML Parser for Java and Java Stored Procedures together with Oracle Streams AQ to obtain metadata such as AQ enqueue or dequeue times and JMS header information, based on queries that target certain XML data. You can combine this with using Oracle Text XML search.

> **See Also:** Appendix E, "Full-Text Search over XML Data Without XQuery".

Prevent the Listener from Stopping Until the XML Document Is Processed

When receiving XML messages from clients as messages you may need to process them as soon as they arrive. But each XML document might take several seconds to process. For PL/SQL, one procedure starts the listener, dequeues the message, and calls another procedure to process the XML document. The listener could be held up until the XML document is processed, and messages would accumulate in the queue.

After receiving a message, you can instead submit a job using PL/SQL package `DBMS_JOB`. The job is invoked asynchronously in a different database session.

You can register a PL/SQL callback, which is invoked asynchronously when a message shows up in a queue. PL/SQL callbacks are part of the Oracle Streams AQ notification framework.

HTTPS with AQ

You can use Oracle Streams AQ Internet access to send XML messages to suppliers using HTTPS and receive a response. Using XML, you can enqueue and dequeue messages over HTTP(S) securely and transactionally.

See Also: *Oracle Database Advanced Queuing User's Guide*

Store XML in Oracle Streams AQ Message Payloads

You can store XML data in Oracle Streams AQ message payloads natively other than having an ADT as the payload with `SYS.XMLType` as part of the ADT. You can create queues with payloads and attributes as `XMLType`.

iDAP and SOAP

iDAP is the SOAP specification for AQ operations. iDAP is the XML specification for Oracle Streams AQ operations. SOAP defines a generic mechanism to invoke a service. iDAP defines these mechanisms to perform AQ operations.

iDAP has the following key properties not defined by SOAP:

- Transactional behavior. You can perform AQ operations in a transactional manner. A transaction can span multiple iDAP requests.
- Security. iDAP operations can be carried out only by authorized and authenticated users.

Part VIII

JSON

Part VIII of this manual contains the following chapter:

- Chapter 39, "JSON in Oracle Database"

39

JSON in Oracle Database

This chapter describes how to use the JavaScript Object Notation (JSON) with Oracle Database. It covers native Oracle Database support for JSON, including querying and indexing.

The chapter contains these topics:

Overview of JSON

JavaScript Object Notation (**JSON**) is defined in standards ECMA-404 (JSON Data Interchange Format) and ECMA-262 (ECMAScript Language Specification, third edition). The JavaScript dialect of ECMAScript is a general programming language used widely in web browsers and web servers.

JSON is almost a subset of the object literal notation of JavaScript.[1] Because it can be used to represent JavaScript object literals, JSON commonly serves as a data-interchange language. In this it has much in common with XML.

Because it is (almost a subset of) JavaScript notation, JSON can often be used in JavaScript programs without any need for parsing or serializing. It is a text-based way of representing JavaScript object literals, arrays, and scalar data.

[1] JSON differs from JavaScript notation in this respect: JSON allows unescaped Unicode characters U+2028 (LINE SEPARATOR) and U+2029 (PARAGRAPH SEPARATOR) in strings. JavaScript notation requires control characters such as these to be escaped in strings. This difference can be important when generating JSONP (JSON with padding) data.

Although it was defined in the context of JavaScript, JSON is in fact a language-independent data format. A variety of programming languages can parse and generate JSON data.

JSON is relatively easy for humans to read and write, and easy for software to parse and generate. It is often used for serializing structured data and exchanging it over a network, typically between a server and web applications.

See Also:

- http://www.ecma-international.org/publications/standards/Ecma-404.htm and http://tools.ietf.org/html/rfc4627 for the definition of the JSON Data Interchange Format
- http://www.ecma-international.org/publications/standards/Ecma-262.htm for the ECMAScript Language Specification
- http://www.json.org for information about JSON
- http://www.ecmascript.org for information about ECMAScript (JavaScript)

Overview of JSON Syntax and the Data It Represents

A JSON **value** is one of the following: object, array, number, string, **`true`**, **`false`**, or **`null`**. All values except objects and arrays are **scalar**.

Note: A JSON value of `null` is a *value* as far as SQL is concerned. It is not `NULL`, which in SQL represents the *absence* of a value (missing, unknown, or inapplicable data). In particular, SQL condition `IS NULL` condition returns false for a JSON null value, and SQL condition `IS NOT NULL` returns true.

A **JavaScript object** is an associative array, or dictionary, of zero or more pairs of **property** names and associated JSON values.[2] A **JSON object** is a **JavaScript object literal**.[3] It is written as such a property list enclosed in braces (**`{`**, **`}`**), with name-value pairs separated by commas (**`,`**), and with the name and value of each pair separated by a colon (**`:`**).

In JSON each property name and each string value *must* be enclosed in double quotation marks (**`"`**). In JavaScript notation, a property name used in an object literal can be, but need not be, enclosed in double quotation marks. It can also be enclosed in single quotation marks (**`'`**).

As a result of this difference, in practice, data that is represented using unquoted or single-quoted property names is sometimes referred to loosely as being represented in JSON, and some implementations of JSON, including the Oracle Database implementation, support the lax syntax that allows the use of unquoted and single-quoted property names.

A string in JSON is composed of Unicode characters, with backslash (**`\`**) escaping. A JSON number (numeral) is represented in decimal notation, possibly signed and possibly including a decimal exponent.

[2] JavaScript objects are thus similar to hash tables in C and C++, HashMaps in Java, associative arrays in PHP, dictionaries in Python, and hashes in Perl and Ruby.

[3] An object is created in JavaScript using either constructor `Object` or object literal syntax: `{...}`.

An object property is sometimes called a **key**. An object property name-value pair is sometimes called an object **member**. Order is not significant among object members.

> **Note:** Each key in a given JSON object is not necessarily unique; the same key may be repeated. The JSON path evaluation that Oracle Database employs always uses only one of the object members that have a given key; any other members with the same key are ignored. It is unspecified which of multiple such members is used.
>
> See also "Unique Versus Duplicate Keys in JSON Objects" on page 39-17.

A **JavaScript array** has zero or more elements. In JSON an array is represented by brackets (`[`, `]`) surrounding the representations of the array **elements**, which are separated by commas (`,`), and each of which is an object, an array, or a scalar value. Array element order is significant.

Example 39–1 shows a JSON object that represents a purchase order, with top-level property names `PONumber`, `Reference`, `Requestor`, `User`, `Costcenter`, `ShippingInstruction`, `Special Instructions`, `AllowPartialShipment` and `LineItems`.

Example 39–1 A JSON Object (Representation of a JavaScript Object Literal)

```
{ "PONumber"             : 1600,
  "Reference"            : "ABULL-20140421",
  "Requestor"            : "Alexis Bull",
  "User"                 : "ABULL",
  "CostCenter"           : "A50",
  "ShippingInstructions" : { "name"    : "Alexis Bull",
                             "Address": { "street"  : "200 Sporting Green",
                                          "city"    : "South San Francisco",
                                          "state"   : "CA",
                                          "zipCode" : 99236,
                                          "country" : "United States of America" },
                             "Phone" : [ { "type" : "Office", "number" : "909-555-7307" },
                                         { "type" : "Mobile", "number" : "415-555-1234" } ] },
  "Special Instructions" : null,
  "AllowPartialShipment" : false,
  "LineItems"            : [ { "ItemNumber" : 1,
                               "Part"       : { "Description" : "One Magic Christmas",
                                                "UnitPrice"   : 19.95,
                                                "UPCCode"     : 13131092899 },
                               "Quantity"   : 9.0 },
                             { "ItemNumber" : 2,
                               "Part"       : { "Description" : "Lethal Weapon",
                                                "UnitPrice"   : 19.95,
                                                "UPCCode"     : 85391628927 },
                               "Quantity"   : 5.0 } ] }
```

- Most of the properties have string values. For example: property `User` has value `"ABULL"`.
- Properties `PONumber` and `zipCode` have numeric values: `1600` and `99236`.
- Property `Shipping Instructions` has an object as value. This object has three members, with properties `name`, `Address`, and `Phone`. Property `name` has a string value (`"Alexis Bull"`). Properties `Address` and `Phone` each have an object value.

- The value of property `Address` is an object with properties `street`, `city`, `state`, `zipCode`, and `country`. Property `zipCode` has a numeric value; the others have string values.
- Property `Phone` has an array as value. This array has two elements, each of which represents an object literal. Each of these objects has two members: properties `type` and `number` and their values.
- Property `Special Instructions` has a `null` value.
- Property `AllowPartialShipment` has the Boolean value `true`.
- Property `LineItems` has an array as value. This array has two elements, each of which is an object. Each of these objects has three members, with keys `ItemNumber`, `Part`, and `Quantity`.
- Properties `ItemNumber` and `Quantity` have numeric values. Property `Part` has an object as value, with properties `Description`, `UnitPrice`, and `UPCCode`. Property `Description` has a string value. Properties `UnitPrice` and `UPCCode` have numeric values.

See Also:

- "About Strict and Lax JSON Syntax" on page 39-17
- Example 39–4 on page 39-15

Overview of JSON Compared with XML

Both JSON and XML (Extensible Markup Language) are commonly used as data-interchange languages. Here is a brief list of some of their differences.

- JSON data types are few and predefined. XML data can be either typeless or based on an XML schema or a document type definition (DTD).
- JSON has simple structure-defining and document-combining constructs: it lacks attributes, namespaces, inheritance and substitution.
- The order of the members of a JavaScript object literal is insignificant. In general, order matters within an XML document.
- JSON lacks an equivalent of XML text nodes (XPath node test `text()`). In particular, this means that there is no mixed content.

JSON is most useful with simple, structured data. XML is useful for both structured and semi-structured data. JSON is generally data-centric, not document-centric; XML can be either. JSONis not a markup language; it is designed only for data representation. XML is both a document markup language and a data representation language.

Because of its simple definition and features, JSON data is generally easier to generate, parse, and process than XML data. Use cases that involve combining different data sources generally lend themselves well to the use of XML, because it offers namespaces and other constructs facilitating modularity and inheritance.

JSON, unlike XML (and unlike JavaScript), has no date data type. A date is represented in JSON using the available data types, such as string. There are some de facto standards for converting between real dates and strings. But programs using JSON must, one way or another, deal with date representation conversion.

Overview of JSON in Oracle Database

JSON data and XML data can be used in Oracle Database in similar ways. Unlike relational data, both can be stored, indexed, and queried in the database *without any need for a schema* that defines the data.

JSON data has often been stored in NoSQL databases such as Oracle NoSQL Database and Oracle Berkeley DB. These allow for storage and retrieval of data that is not based on any schema, but they do not offer the rigorous consistency models of relational databases.

To compensate for this shortcoming, a relational database is sometimes used in parallel with a NoSQL database. Applications using JSON data stored in the NoSQL database must then ensure data integrity themselves.

Oracle Database supports JSON natively with relational database features, including transactions, indexing, declarative querying, and views.

Oracle Database queries are declarative. You can join JSON data with relational data. And you can project JSON data relationally, making it available for relational processes and tools. You can also query, from within the database, JSON data that is stored outside the database in an external table.

You can access JSON data stored in the database the same way you access other database data, including using OCI, .NET, and JDBC.

Unlike XML data, which is stored using SQL data type `XMLType`, JSON data is stored in Oracle Database using SQL data types `VARCHAR2`, `CLOB`, and `BLOB`. Oracle recommends that you always use an `is_json` check constraint to ensure that column values are valid JSON instances (see Example 39–3).

JSON data in the database is textual, but the text can be stored using data type `BLOB`, as well as `VARCHAR2` or `CLOB`.

When JSON data is stored in a `BLOB` column you must use keywords `FORMAT JSON` in queries that use Oracle SQL functions or conditions for JSON (`json_value`, `json_query`, `json_table`, `json_exists`), to declare that the data is JSON. Otherwise, an error is raised, letting you know that the JSON input data is binary and you have not specified its format.

Note: Oracle recommends that whenever you store JSON data in a `BLOB` or `CLOB` column you *turn on the LOB cache option* for that column. This option is turned off by default. See *Oracle Database SecureFiles and Large Objects Developer's Guide*.

By definition, textual JSON data is encoded using a Unicode encoding, either UTF8 or UTF16. You can use textual data that is stored in a non-Unicode character set as if it were JSON data, but in that case Oracle Database automatically converts the character set to UTF8 when processing the data.

In SQL, you can access JSON data stored in Oracle Database using the following:

- Functions `json_value`, `json_query`, `and json_table`.
- Conditions `json_exists`, `is json`, `is not json`, and `json_textcontains`.
- A dot notation that acts similar to a combination of `json_value` and `json_query` and resembles a SQL object access expression, that is, attribute dot notation for an abstract data type (ADT).

As a simple illustration, Example 39–2 uses the dot notation to query JSON column `po_document` for all purchase-order requestors (JSON object key `Requestor`).

Example 39–2 Simple SQL Query of JSON Data

```
SELECT po.po_document.Requestor FROM j_purchaseorder po;
```

See Also:

- "Oracle JSON Path Expressions" on page 39-8
- "Oracle SQL Functions and Conditions for Use with JSON Data" on page 39-12
- "Simple Dot-Notation Access to JSON Data" on page 39-29
- "Oracle Database Support for JSON" on page 39-38
- "JSON: Character Sets and Character Encoding in Oracle Database" on page 39-7 for information about automatic character-set conversion

Getting Started Using JSON with Oracle Database

In general, you will perform the following tasks when working with JSON data in Oracle Database:

1. Create a relational table with a JSON column, and add an `is json` *check constraint* to ensure that the column contains only well-formed JSON data.

   The following statement creates relational table `j_purchaseorder` with JSON column `po_document` (see also Example 39–3 on page 39-15):

   ```
   CREATE TABLE j_purchaseorder
      (id          RAW (16) NOT NULL,
       date_loaded TIMESTAMP WITH TIME ZONE,
       po_document CLOB
       CONSTRAINT ensure_json CHECK (po_document IS JSON));
   ```

2. Insert JSON data into the JSON column, using any of the methods available for Oracle Database.

   The following statement uses a SQL `INSERT` statement to insert some simple JSON data. Some of the data is elided here (. . .). See Example 39–4 on page 39-15 for these details.

   ```
   INSERT INTO j_purchaseorder
     VALUES (SYS_GUID(),
             SYSTIMESTAMP,
             '{"PONumber"             : 1600,
               "Reference"            : "ABULL-20140421",
               "Requestor"            : "Alexis Bull",
               "User"                 : "ABULL",
               "CostCenter"           : "A50",
               "ShippingInstructions" : {...},
               "Special Instructions" : null,
               "AllowPartialShipment" : true,
               "LineItems"            : [...]}');
   ```

3. Query the JSON data. The return value is always a `VARCHAR2` instance that represents a JSON value. Here are some simple examples.

The following query extracts, from each JSON document in column `po_document`, a *scalar* value, the JSON number that is the value of property `PONumber` for the objects in JSON column `po_document` (see also Example 39–18 on page 39-31):

```
SELECT po.po_document.PONumber FROM j_purchaseorder po;
```

The following query extracts, from each document in JSON column `po_document`, an *array* of JSON phone objects, which is the value of object property `Phone` of the value of object property `ShippingInstructions` (see also Example 39–19 on page 39-31):

```
SELECT po.po_document.ShippingInstructions.Phone FROM j_purchaseorder po;
```

The following query extracts, from each JSON document, *multiple* values as an array: the value of object property `type` for each object in array `Phone`. The returned array is not part of the stored data but is constructed automatically by the query. (The order of the array elements is unspecified.)

```
SELECT po.po_document.ShippingInstructions.Phone.type FROM j_purchaseorder po;
```

See Also:

- "Using a Check Constraint To Ensure that a Column Contains JSON Data" on page 39-15
- "Simple Dot-Notation Access to JSON Data" on page 39-29

JSON: Character Sets and Character Encoding in Oracle Database

Textual JSON data always uses the Unicode character set. In this respect, JSON data is simpler to use than XML data. This is an important part of the JSON Data Interchange Format (RFC 4627).

Oracle Database uses UTF8 internally when it processes JSON data (parsing, querying). If the data that is input to such processing, or the data that is output from it, must be in a different character set from UTF8, then appropriate character-set conversion is carried out automatically.

Character-set conversion can affect performance. And in some cases it can be lossy: Conversion of input data to UTF8 is a lossless operation, but conversion to output can result in *information loss* in the case of characters that cannot be represented in the output character set.

If your textual JSON data is stored in the database as Unicode then no character-set conversion is needed. This is the case if the database character set is AL32UTF8 (Unicode UTF8). Oracle recommends this if at all possible.

JSON data that is not stored textually, that is, as characters, never undergoes character-set conversion: there are no characters to convert. This means that JSON data stored using data type `BLOB` suffers no character-set conversion.

If your JSON data is stored as non-Unicode character data, that is, using non-Unicode `VARCHAR2` or `CLOB` storage, then consider doing the following to avoid character-set conversion:

- Use `NUMBER`, not `VARCHAR2`, for the return value of Oracle SQL functions such as `json_value`.
- Escape particular Unicode characters on input—see "Escape of Unicode Characters in JSON Data" on page 39-8

See Also:

- http://www.unicode.org for information about Unicode
- http://tools.ietf.org/html/rfc4627 and http://www.ecma-international.org/publications/standards/Ecma-404.htm for the JSON Data Interchange Format
- *Oracle Database Migration Assistant for Unicode Guide* for information about using different character sets with the database
- *Oracle Database Globalization Support Guide* for information about character-set conversion in the database

Escape of Unicode Characters in JSON Data

ASCII characters correspond directly to the first 128 Unicode characters. If your application can use an ASCII escape sequence to represent input Unicode characters that might otherwise require character-set conversion, then you will avoid any possible performance penalty or information loss from such conversion.

An ASCII escape sequence for a Unicode character is **\u** followed by four ASCII hexadecimal digits representing the Unicode code point for the character.

For example, the Unicode euro character €, which is named `EURO SIGN`, has code point `20AC` (using hexadecimal digits), so it can be represented using the ASCII escape sequence `\u20AC`.

You can use explicit ASCII escaping on *input* data. Because JSON data uses Unicode internally, when it is *output*, character-set conversion still applies, by default. However, for Oracle SQL functions `json_value`, `json_query`, and `json_table` you can use keyword **`ASCII`** to specify the automatic use of ASCII escape sequences for non-ASCII Unicode characters.

See Also: "RETURNING Clause for Oracle SQL Functions for JSON" on page 39-13

Oracle JSON Path Expressions

JSON is a notation for JavaScript values. When JSON data is stored in the database it is possible to query it using path expressions that are somewhat analogous to XQuery or XPath expressions for XML data. Similar to the way that SQL/XML allows SQL access to XML data using XQuery expressions, Oracle Database provides SQL access to JSON data using Oracle JSON path expressions.

Oracle JSON path expressions have a simple syntax. An Oracle JSON path expression selects zero or more JSON values that match, or satisfy, it.

Oracle SQL condition `json_exists` returns true if at least one value matches, and false if no value matches. If a single value matches, then SQL function `json_value` returns that value if it is scalar and raises an error if it is non-scalar. If no value matches the path expression then `json_value` returns SQL `NULL`.

Oracle SQL function `json_query` returns all of the matching values, that is, it can return multiple values. You can think of this behavior as returning a sequence of values, as in XQuery, or you can think of it as returning multiple values. (No user-visible sequence is manifested.)

In all cases, path-expression matching attempts to match each *step* of the path expression, in turn. If matching any step fails then no attempt is made to match the

subsequent steps, and matching of the path expression fails. If matching each step succeeds then matching of the path expression succeeds.

> **See Also:** "Oracle JSON Path Expression Syntax" on page 39-9 for information about path-expression steps

Oracle JSON Path Expression Syntax

Oracle JSON path expression syntax is an extension of JSON syntax. In particular, path expressions can use wildcards and array ranges.

You pass an Oracle JSON path expression and some JSON data to an Oracle SQL function or condition. The path expression is matched against the data, and the matching data is processed by the particular SQL function or condition. You can think of this matching process in terms of the path expression *returning* the matched data to the function or condition.

> **See Also:**
>
> - "Oracle JSON Basic Path Expression Syntax" on page 39-9
> - "Oracle JSON Path Expression Syntax Relaxation" on page 39-10
> - "Oracle SQL Functions and Conditions for Use with JSON Data" on page 39-12
> - "About Strict and Lax JSON Syntax" on page 39-17

Oracle JSON Basic Path Expression Syntax

The basic syntax of an Oracle JSON path expression is as follows. However, this basic syntax is extended by relaxing the matching of arrays and non-arrays against non-array and array patterns, respectively: see "Oracle JSON Path Expression Syntax Relaxation" on page 39-10.

- An Oracle JSON path expression begins with a dollar sign (`$`), which represents the path-expression **context item**, that is, the JSON data to be matched. That data is the result of evaluating a SQL expression that is passed as argument to the Oracle SQL function.

  The dollar sign is followed by zero or more **steps**, each of which can be an object step or an array step, depending on whether the context item represents a JSON object or a JSON array.

- An **object step** is a period (`.`), sometimes read as "dot", followed by an object property (key) name or an asterisk (`*`) wildcard, which stands for (the values of) *all* properties. A property name must start with an uppercase or lowercase letter A to Z and contain only such letters or decimal digits (0-9), or else it must be enclosed in double quotation marks (`"`). An object step returns the *value* of the property (key) that is specified. If a wildcard is used for the property then the step returns the *values* of all properties, in no special order.

- An **array step** is a left bracket (`[`) followed by *either* an asterisk (`*`) wildcard, which stands for *all* array elements, *or* one or more specific array indexes or range specifications separated by commas, followed by a right bracket (`]`). In a path expression, array indexing is zero-based (0, 1, 2,...), as in the JavaScript convention for arrays. A range specification has the form `N` to `M`, where `N` and `M` are array indexes and `N` is strictly less than `M`. (An error is raised at query compilation time if

N is not less than *M*.) An error is raised if you use both an asterisk and either an array index or range specification.

When indexes or range specifications are used, the array elements they collectively specify must be specified in ascending order, without repetitions, or else a compile-time error is raised. For example, an error is raised for each of `[3, 1 to 4]`, `[4, 2]`, `[2, 3 to 3]`, and `[2, 3, 3]`, the first two because the order is not ascending and the last two because of the repeated element `3`.

Similarly, the elements in the array value that results from matching are in ascending order, with no repetitions. If an asterisk is used in the path expression then all of the array elements are returned, in array order.

Here are some examples of path expressions, with their meanings spelled out in detail.

- `$` – The context item.
- `$.friends` – The value of property `friends` of the context-item object. The dotted notation indicates that the context item is a JSON object.
- `$.friends[0]` – The object that is the first element of the array that is the value of property `friends` of the context-item object. The bracket notation indicates that the value of property `friends` is an array.
- `$.friends[0].name` – Value of property `name` of the object that is the first element of the array that is the value of property `friends` of the context-item object. The second dot indicates that the first element of array `friends` is an object (with a `name` property).
- `$.friends[*].name` – Value of property `name` of *each* object in the array that is the value of property `friends` of the context-item object.
- `$.*[*].name` – Property `name` values for each object in an array value of a property of the context-item object.
- `$.friends[12, 3, 8 to 10]` – The twelfth, third, eighth, ninth, and tenth elements of array `friends` (property of the context-item object). The elements are returned in array order: third, eighth, ninth, tenth, twelfth.
- `$friends[3].cars` – The value of property `cars` of the object that is the third element of array `friends`. The dot indicates that the third element is an object (with a `cars` property).
- `$friends[3].*` – The values of *all* of the properties of the object that is the third element of array `friends`.
- `$friends[3].cars[0].year` – The value of property `year` of the object that is the first element of the array that is the value of property `cars` of the object that is the third element of the array that is bound to variable `friends`.

See Also: "Oracle JSON Path Expression Syntax Relaxation" on page 39-10

Oracle JSON Path Expression Syntax Relaxation

"Oracle JSON Basic Path Expression Syntax" on page 39-9 defines the basic Oracle JSON path-expression syntax. The actual path expression syntax supported relaxes that definition as follows:

- If a path-expression step targets (expects) an array but the actual data presents no array then the data is implicitly wrapped in an array.

- If a path-expression step targets (expects) a non-array but the actual data presents an array then the array is implicitly unwrapped.

This relaxation allows for the following abbreviation: **`[*]`** can be elided whenever it precedes the object accessor, **`.`**, followed by an object property name, with no change in effect. The reverse is also true: **`[*]`** can always be inserted in front of the object accessor, **`.`**, with no change in effect.

This means that the object step `[*].`*`prop`*, which stands for the value of property *`prop`* of each element of a given array of objects, can be abbreviated as `.`*`prop`*, and the object step `.`*`prop`*, which looks as though it stands for the *`prop`* value of a single object, stands also for the *`prop`* value of each element of an array to which the object accessor is applied.

This is an important feature, because it means that you need not change a path expression in your code if your data evolves to replace a given JSON value with an array of such values, or vice versa.

For example, if your data originally contains objects that have property `Phone` whose value is a single object with properties `type` and `number`, the path expression `$.Phone.number`, which matches a single phone number, can still be used if the data evolves to represent an array of phones. Path expression `$.Phone.number` matches either a single phone object, selecting its number, or an array of phone objects, selecting the number of each.

Similarly, if your data mixes both kinds of representation—there are some data entries that use a single phone object and some that use an array of phone objects, or even some entries that use both—you can use the same path expression to access the phone information from these different kinds of entry.

Here are some example path expressions from section "Oracle JSON Basic Path Expression Syntax" on page 39-9, together with an explanation of equivalences.

- `$.friends` – The value of property `friends` of *either*:
  - The (single) context-item object.
  - (equivalent to `$[*].friends`) Each object in the context-item array.
- `$.friends[0].name` – Value of property `name` for *any* of these objects:
  - The first element of the array that is the value of property `friends` of the context-item object.
  - (equivalent to `$.friends.name`) The value of property `friends` of the context-item object.
  - (equivalent to `$[*].friends.name`) The value of property `friends` of each object in the context-item array.
  - (equivalent to `$[*].friends[0].name`) The first element of each array that is the value of property `friends` of each object in the context-item array.

  The context item can be an object or an array of objects. In the latter case, each object in the array is matched for a property `friends`.

  The value of property `friends` can be an object or an array of objects. In the latter case, the first object in the array is used.
- `$.*[*].name` – Value of property `name` for *any* of these objects:
  - An element of an array value of a property of the context-item object.
  - (equivalent to `$.*.name`) The value of a property of the context-item object.

- (equivalent to `$[*].*.name`) The value of a property of an object in the context-item array.
- (equivalent to `$[*].*[*].name`) Each object in an array value of a property of an object in the context-item array.

See Also: "Oracle JSON Basic Path Expression Syntax" on page 39-9

Oracle SQL Functions and Conditions for Use with JSON Data

This section describes Oracle SQL functions and conditions that you can use to create, query, and operate on JSON data stored in Oracle Database.

Some of these take as argument an Oracle JSON path expression as a literal SQL string, followed possibly by a `RETURNING` clause, a wrapper clause, or an error clause.

These are the Oracle SQL functions and conditions described here:

- Oracle SQL Conditions IS JSON and IS NOT JSON – test whether some data is well-formed JSON data. Used especially as a check constraint.
- Oracle SQL Condition JSON_EXISTS – test for the existence of a particular value within some JSON data.
- Oracle SQL Function JSON_VALUE – select a scalar value from some JSON data, as a SQL value.
- Oracle SQL Function JSON_QUERY – select one or more values from some JSON data, as a SQL string representing the JSON values. Used especially to retrieve fragments of a JSON document, typically a JSON object or array.
- Oracle SQL Function JSON_TABLE – project some JSON data to a relational format as a virtual table, which you can also think of as an inline relational view.

See Also:

- "Oracle JSON Path Expressions" on page 39-8
- "Clauses Used in Oracle SQL Functions and Conditions for JSON" on page 39-12
- *Oracle Database SQL Language Reference* for complete information about the syntax and semantics of the Oracle SQL functions that create, query, and operate on JSON data.
- "Simple Dot-Notation Access to JSON Data" on page 39-29
- "Full-Text Search of JSON Data" on page 39-36 for information about full-text searching JSON data using Oracle SQL condition `json_textcontains`
- *Oracle Database SQL Language Reference* for information about Oracle SQL condition `json_textcontains`

Clauses Used in Oracle SQL Functions and Conditions for JSON

This section describes the `RETURNING`, wrapper, and error handling clauses used in one or more of the Oracle SQL functions and conditions `json_value`, `json_query`, `json_table`, `is json`, `is not json`, and `json_exists`.

RETURNING Clause for Oracle SQL Functions for JSON

The optional **RETURNING** clause specifies the data type of the value returned by the Oracle SQL function. In general, you can use the name of either of these SQL data types: `VARCHAR2` or `NUMBER`. You can optionally specify a length for `VARCHAR2` (default: `4000`) and a precision and scale for `NUMBER`.

The default behavior (no `RETURNING` clause) is to use `VARCHAR2(4000)`.

The `RETURNING` clause also accepts two optional keywords, `PRETTY` and `ASCII`. If both are present then `PRETTY` must come before `ASCII`. `ASCII` is allowed only for Oracle SQL functions `json_value` and `json_query`. `PRETTY` is allowed only for `json_query`.

The effect of keyword **PRETTY** is to pretty-print the returned data, by inserting newline characters and indenting. The default behavior is not to pretty-print.

The effect of keyword **ASCII** is to automatically escape all non-ASCII Unicode characters in the returned data, using standard ASCII Unicode escape sequences. The default behavior is not to escape non-ASCII Unicode characters.

> **Tip:** You can pretty-print the entire context item by using only `$` as the path expression.

> **See Also:** "Escape of Unicode Characters in JSON Data" on page 39-8

Wrapper Clause for Oracle SQL Functions JSON_QUERY and JSON_TABLE

The optional wrapper clause is only for Oracle SQL functions `json_query` and `json_table`. It specifies the form of the value returned by `json_query` or used for the data in a `json_table` relational column.

The wrapper clause takes one of these forms:

- **WITH WRAPPER** – Use a string value that represents a JSON array containing *all* of the JSON values that match the path expression. The order of the array elements is unspecified.
- **WITHOUT WRAPPER** – Use a string value that represents the *single* JSON *object* or *array* that matches the path expression. Raise an error if the path expression matches either a scalar value (not an object or array) or more than one value.
- **WITH CONDITIONAL WRAPPER** – Use a string value that represents *all* of the JSON values that match the path expression. For zero values, a single scalar value, or multiple values, `WITH CONDITIONAL WRAPPER` is the same as `WITH WRAPPER`. For a single JSON object or array value, it is the same as `WITHOUT WRAPPER`.

The default behavior is `WITHOUT WRAPPER`.

You can add the optional keyword **UNCONDITIONAL** immediately after keyword `WITH`, if you find it clearer: `WITH WRAPPER` and `WITH UNCONDITIONAL WRAPPER` mean the same thing.

You can add the optional keyword **ARRAY** immediately before keyword `WRAPPER`, if you find it clearer: `WRAPPER` and `ARRAY WRAPPER` mean the same thing.

Table 39–1 illustrates the wrapper clause possibilities. The array wrapper is shown in bold.

Table 39–1 JSON_QUERY Wrapper Clause Examples

JSON Values Matching Path Expression	WITH WRAPPER	WITHOUT WRAPPER	WITH CONDITIONAL WRAPPER
`{"id": 38327}` (single object)	`[{"id": 38327}]`	`{"id": 38327}`	`{"id": 38327}`
`[42, "a", true]` (single array)	`[[42, "a", true]]`	`[42, "a", true]`	`[42, "a", true]`
`42`	`[42]`	Error (scalar)	`[42]`
`42,"a",true`	`[42, "a", true]`	Error (multiple values)	`[42, "a", true]`
none	`[]`	Error (no values)	`[]`

Consider, for example, a `json_query` query to retrieve a JSON object. What happens if the path expression matches a JSON scalar value instead of an object, or it matches multiple JSON values (of any kind)? You might want to retrieve the matched values instead of raising an error. For example, you might want to pick one of the values that is an object, for further processing. Using an array wrapper lets you do this.

A conditional wrapper can be convenient if the only reason you are using a wrapper is to avoid raising an error and you do not need to distinguish those error cases from non-error cases. If your application is looking for a single object or array and the data matched by a path expression is just that, then there is no need to wrap that expected value in a singleton array.

On the other hand, with an unconditional wrapper you know that the resulting array is always a wrapper—your application can count on that. If you use a conditional wrapper then your application might need extra processing to interpret a returned array. In Table 39–1, for instance, note that the same array (`[42, "a", true]`) is returned for the very different cases of a path expression matching that array and a path expression matching each of its elements.

Error Clause for Oracle SQL Functions for JSON

The optional error clause specifies handling for an error that is raised by the Oracle SQL function or condition. The clause takes one of these forms:

- **`ERROR ON ERROR`** – Raise the error (no special handling).
- **`NULL ON ERROR`** – Return `NULL` instead of raising the error.
- **`TRUE ON ERROR`** – Return true instead of raising the error. This form of the clause is available only for Oracle SQL condition `json_exists`.
- **`FALSE ON ERROR`** – Return false instead of raising the error. This form of the clause is available only for Oracle SQL condition `json_exists`.
- **`EMPTY ON ERROR`** – Return an empty array (`[]`) instead of raising the error. This form of the clause is available only for Oracle SQL function `json_query`.
- **`DEFAULT '`***`literal_return_value`***`' ON ERROR`** – Return the specified value instead of raising the error. The value must be a constant at query compile time. This form of the clause is not available for `json_query`.

The *default* behavior is `NULL ON ERROR`.

Note: The `ON ERROR` clause takes effect only for runtime errors that arise when a syntactically correct Oracle JSON path expression is matched against JSON data. A path expression that is syntactically incorrect results in a compile-time syntax error; it is not handled by the `ON ERROR` clause.

Oracle SQL Conditions IS JSON and IS NOT JSON

Oracle SQL conditions `is json` and `is not json` are complementary. You can use them in a `CASE` expression or the `WHERE` clause of a `SELECT` statement.

They test whether their argument is syntactically correct, that is, *well-formed*, as JSON data. If so, then `is json` returns true and `is not json` returns false. If the argument cannot be evaluated for some reason (for example, if an error occurs during parsing) then the data is simply considered to not be well-formed: `is json` returns false; `is not json` returns true. **Well-formedness** implies that the data is syntactically correct. (JSON data can be well formed in two senses, which we refer to as strict and lax syntax.)

See Also:

- *Oracle Database SQL Language Reference* for information about `is json` and `is not json`.
- "About Strict and Lax JSON Syntax" on page 39-17

Using a Check Constraint To Ensure that a Column Contains JSON Data

A typical use of `is json` is as a check constraint, to ensure that the data in a JSON column is (well-formed) JSON data.

Example 39–3 and Example 39–4 illustrate this. They create and fill a table that holds data used in the examples in this chapter.

For brevity, only one row of data (one JSON document) is inserted in Example 39–4. See "Loading External JSON Data" on page 39-37 for examples that insert the full set of data.

Note: Oracle recommends that you *always* use an `is_json` check constraint when you create a column intended for JSON data.

Example 39–3 Using IS JSON in a Check Constraint to Ensure JSON Data is Well-Formed

```
CREATE TABLE j_purchaseorder
   (id          RAW (16) NOT NULL,
    date_loaded TIMESTAMP (6) WITH TIME ZONE,
    po_document CLOB
    CONSTRAINT ensure_json CHECK (po_document IS JSON));
```

Example 39–4 Inserting Data into a Relational Table with a JSON Column

```
INSERT INTO j_purchaseorder
  VALUES (
    SYS_GUID(),
    SYSTIMESTAMP,
```

```
'{"PONumber"             : 1600,
  "Reference"            : "ABULL-20140421",
  "Requestor"            : "Alexis Bull",
  "User"                 : "ABULL",
  "CostCenter"           : "A50",
  "ShippingInstructions" : {"name"   : "Alexis Bull",
                            "Address": {"street"  : "200 Sporting Green",
                                        "city"    : "South San Francisco",
                                        "state"   : "CA",
                                        "zipCode" : 99236,
                                        "country" : "United States of America"},
                            "Phone" : [{"type" : "Office", "number" : "909-555-7307"},
                                       {"type" : "Mobile", "number" : "415-555-1234"}]},
  "Special Instructions" : null,
  "AllowPartialShipment" : true,
  "LineItems"            : [{"ItemNumber" : 1,
                             "Part"       : {"Description" : "One Magic Christmas",
                                             "UnitPrice"   : 19.95,
                                             "UPCCode"     : 13131092899},
                             "Quantity"   : 9.0},
                            {"ItemNumber" : 2,
                             "Part"       : {"Description" : "Lethal Weapon",
                                             "UnitPrice"   : 19.95,
                                             "UPCCode"     : 85391628927},
                             "Quantity"   : 5.0}]}');
```

Note: Oracle SQL conditions `IS JSON` and `IS NOT JSON` return true or false for any non-`NULL` SQL value. But they both return unknown (neither true nor false) for SQL `NULL`. When used in a check constraint, they do not prevent a `NULL` value from being inserted. But when used in a SQL `WHERE` clause, `NULL` is never selected (returned).

It is true that a check constraint can reduce performance for data insertion. If you are sure that your application inserts only well-formed JSON data into a particular column, then consider *disabling* the check constraint, but *do not drop* the constraint.

See Also:

- "Determining Whether a Column Necessarily Contains JSON Data" on page 39-16
- "Loading External JSON Data" on page 39-37 for the creation of the full table `j_purchaseorder`

Determining Whether a Column Necessarily Contains JSON Data

How can you tell whether a given column has a check constraint that ensures that its data is well-formed JSON data? Whenever this is the case[4], the column is listed in the following static data dictionary views:

- **`DBA_JSON_COLUMNS`**
- **`USER_JSON_COLUMNS`**

[4] If the check constraint combines condition `is json` with another condition using logical condition `OR`, then the column is *not* listed in these views. In this case, it is not certain that data in the column is JSON data. For example, the constraint `jcol is json` **`OR`** `length(jcol) < 1000` does *not* ensure that the data in column `jcol` is JSON data.

- **ALL_JSON_COLUMNS**

Each view lists the names of the owner, table, and column, as well as the data type of the column. You can query this data to find JSON columns.

Note that even if the check constraint that ensures that the data is JSON is *deactivated*, the column remains listed in the views. If the check constraint is *dropped* then the column is removed from the views.

> **See Also:** "Using a Check Constraint To Ensure that a Column Contains JSON Data" on page 39-15

Unique Versus Duplicate Keys in JSON Objects

The JSON standard does not specify whether property (key) names must be unique for a given JSON object. This means that, a priori, a well-formed JSON object can have multiple members that have the same key. This is the default behavior for handling JSON data in Oracle Database.

You can specify that particular JSON data is to be considered well-formed only if all objects it contains have unique keys, that is, no object has duplicate key names. You do this by using the keywords **WITH UNIQUE KEYS** with Oracle SQL condition `is json`. If you do not specify `UNIQUE KEYS`, or if you use the keywords **WITHOUT UNIQUE KEYS**, then objects can have duplicate key names and still be considered well-formed.

The evaluation that Oracle Database employs always uses only one of the object members that have a given key; any other members with the same key are ignored. It is unspecified which of multiple such members is used.

Whether duplicate keys are allowed in well-formed JSON data is orthogonal to whether Oracle uses strict or lax syntax to determine well-formedness.

About Strict and Lax JSON Syntax

Standard ECMA-404, the *JSON Data Interchange Format*, and ECMA-262, the *ECMAScript Language Specification*, define JSON syntax.

According to these specifications, each JSON property (key) name and each string value must be enclosed in double quotation marks (**"**). Oracle supports this **strict JSON syntax**, but it is *not* the default syntax.

In JavaScript notation, a property name used in an object literal can be, but need not be, enclosed in double quotation marks. It can also be enclosed in single quotation marks (**'**). Oracle also supports this **lax JSON syntax**, and it is the *default* syntax.

In addition, in practice, some JavaScript implementations (but not the JavaScript standard) allow one or more of the following:

- Case variations for keywords `true`, `false`, and `null` (for example, `TRUE`, `True`, `TrUe`, `fALSe`, `NulL`).
- An extra comma (**,**) after the last element of an array or the last member of an object (for example, `[a, b, c,]`, `{a:b, c:d,}`).
- Numerals with one or more leading zeros (for example, `0042.3`).
- Fractional numerals that lack `0` before the decimal point (for example, `.14` instead of `0.14`).
- Numerals with no fractional part after the decimal point (for example, `342.` or `1.e27`).

- A plus sign (+) preceding a numeral, meaning that the number is non-negative (for example, `+1.3`).

This syntax too is allowed as part of the Oracle default (lax) JSON syntax. (See the JSON standard for the strict numeral syntax.)

In addition to the ASCII space character (U+0020), the JSON standard defines the following characters as insignificant (ignored) whitespace when used outside a quoted property name or a string value:

- Tab, horizontal tab (`HT`, `^I`, decimal 9, U+0009, `\t`)
- Line feed, newline (`LF`, `^J`, decimal 10, U+000A, `\n`)
- Carriage return (`CR`, `^M`, decimal 13, U+000D, `\r`)

The Oracle JSON lax syntax, however, treats *all* of the ASCII control characters (Control+0 through Control+31), as well as the ASCII space character (decimal 32, U+0020), as (insignificant) whitespace characters. The following are among the control characters:

- Null (`NUL`, `^@`, decimal 0, U+0000, `\0`)
- Bell (`NEL`, `^G`, decimal 7, U+0007, `\a`)
- Vertical tab (`VT`, `^K`, decimal 11, U+000B)
- Escape (`ESC`, `^[`, decimal 27, U+001B, `\e`)
- Delete (`DEL`, `^?`, decimal 127, U+007F)

An ASCII space character (U+0020) is the only whitespace character allowed, unescaped, within a quoted property name or a string value. This is true for both the lax and strict Oracle JSON syntaxes.

For both strict and lax Oracle JSON syntax, quoted object property (key) names and string values can contain any Unicode character, but some of them must be escaped, as follows:

- ASCII control characters are not allowed, except for those represented by the following escape sequences: **`\b`** (backspace), **`\f`** (form feed), **`\n`** (newline, line feed), **`\r`** (carriage return), and **`\t`** (tab, horizontal tab).
- Double quotation mark (**`"`**), slash (**`/`**), and backslash (**`\`**) characters must also be escaped (preceded by a backslash): **`\"`**, **`\/`**, and **`\\`**, respectively.

In the lax Oracle syntax, an object property name that is *not* quoted can contain any Unicode character except whitespace and the JSON structural characters—left and right brackets (**`[`**, **`]`**) and curly braces (**`{`**, **`}`**), colon (**`:`**), and comma (**`,`**), but escape sequences are not allowed.

Any Unicode character can also be included in a name or string by using the ASCII escape syntax **`\u`** followed by the four ASCII hexadecimal digits that represent the Unicode code point.

Note that other Unicode characters that are not printable or that might appear as whitespace, such as a no-break space character (U+00A0), are *not* considered whitespace for either the strict or the lax Oracle JSON syntax.

Table 39–2 shows some examples of JSON syntax.

Table 39–2 JSON Object Property Name Syntax Examples

Example	Well-Formed?
`"part number": 1234`	Lax and strict: yes. Space characters are allowed.
`part number: 1234`	Lax (and strict): **no**. Whitespace characters, including space characters, are not allowed in unquoted names.
`"part\tnumber": 1234`	Lax and strict: yes. Escape sequence for tab character is allowed.
`"part  number": 1234`	Lax and strict: **no**. Unescaped tab character is not allowed. Space is the only unescaped whitespace character allowed.
`"\"part\"number": 1234`	Lax and strict: yes. Escaped double quotation marks are allowed, if name is quoted.
`\"part\"number: 1234`	Lax and strict: **no**. Name must be quoted.
`'\"part\"number': 1234`	Lax: yes, **strict: no**. Single-quoted property names and strings are allowed for lax syntax only. Escaped double quotation mark is allowed in a quoted name.
`"pärt number":1234`	Lax and strict: yes. Any Unicode character is allowed in a quoted name.
`part:number:1234`	Lax (and strict): **no**. Structural characters are not allowed in unquoted names.
`"pärt:number":1234`	**Lax: yes**, strict: no. Structural and Unicode characters other than whitespace are allowed in a quoted name for lax syntax only.

See Also:

- `http://tools.ietf.org/html/rfc4627` and `http://www.ecma-international.org/publications/standards/Ecma-404.htm` for the syntax of JSON Data Interchange Format
- `http://www.ecmascript.org`, http://www.ecma-international.org, and `http://www.json.org` for more information about JSON and JavaScript
- "Overview of JSON Syntax and the Data It Represents" on page 39-2
- "Escape of Unicode Characters in JSON Data" on page 39-8

Specifying Strict or Lax Oracle JSON Syntax

The default Oracle JSON syntax is lax. Strict or lax syntax matters *only* for conditions `is json` and `is not json`. All other Oracle SQL functions and conditions use lax syntax for interpreting input and strict syntax when returning output. If you need to be sure that particular JSON input data has strictly correct syntax, then check it first using `is json` or `is not json`.

You specify that data is to be checked as strictly well-formed according to the JSON standard by appending **`(STRICT)`** (parentheses included) to an `is json` or an `is not json` expression.

Example 39–5 illustrates this. It is identical to Example 39–3 except that it uses `(STRICT)` to ensure that all data inserted into the column is well-formed according to the JSON standard.

Example 39–5 Using IS JSON in a Check Constraint to Ensure JSON Data is Strictly Well-Formed (Standard)

```
CREATE TABLE j_purchaseorder
   (id          RAW (16) NOT NULL,
    date_loaded TIMESTAMP WITH TIME ZONE,
    po_document CLOB
```

```
  CONSTRAINT ensure_json CHECK (po_document IS JSON (STRICT)));
```

See Also: "About Strict and Lax JSON Syntax" on page 39-17

Oracle SQL Condition JSON_EXISTS

Oracle SQL condition `json_exists` lets you use an Oracle JSON path expression as a row filter, to select rows based on the content of JSON documents.

You can use condition `json_exists` in a `CASE` expression or the `WHERE` clause of a `SELECT` statement. It checks for the existence of a particular value within JSON data: it returns true if the value is present and false if it is absent.

More precisely, `json_exists` returns true if the data it targets matches one or more JSON values. If no JSON values are matched then it returns false.

You can also use `json_exists` to create bitmap indexes for use with JSON data—see Example 39–20 on page 39-32.

Error handlers `ERROR ON ERROR`, `FALSE ON ERROR`, and `TRUE ON ERROR` apply. The default is `FALSE ON ERROR`. The handler takes effect when any error occurs, but typically an error occurs when the given JSON data is not well-formed (using lax syntax). Unlike the case for conditions `is json` and `is not json`, condition `json_exists` *expects* the data it examines to be well-formed JSON data.

The second argument to `json_exists` is an Oracle JSON path expression followed by an optional `RETURNING` clause and an optional error clause. The path expression must target a single scalar value, or else a compile-time error is raised.

Note: Oracle SQL function `json_exists` applied to JSON value `null` returns the SQL string `'true'`.

See Also:

- "RETURNING Clause for Oracle SQL Functions for JSON" on page 39-13
- "Error Clause for Oracle SQL Functions for JSON" on page 39-14
- *Oracle Database SQL Language Reference* for information about `json_value`

JSON_EXISTS as JSON_TABLE

Oracle SQL condition `json_exists` can be viewed as a special case of Oracle SQL function `json_table`. Example 39–6 illustrates the equivalence: the two `SELECT` statements have the same effect.

Example 39–6 JSON_EXISTS Expressed Using JSON_TABLE

```
SELECT select_list
  FROM table WHERE json_exists(column, json_path error_handler ON ERROR);

SELECT select_list
  FROM table,
       json_table(column, '$' error_handler ON ERROR
         COLUMNS ("COLUMN_ALIAS" NUMBER EXISTS PATH json_path)) AS "JT"
  WHERE jt.column_alias = 1;
```

In addition to perhaps helping you understand `json_exists` better, this equivalence is important practically, because it means that you can use either to get the same effect.

In particular, if you use `json_exists` more than once, or you use it in combination with `json_value` or `json_query` (which can also be expressed using `json_table`), to access the same data then it is typically more efficient to use a single invocation of `json_table` instead, because the data is parsed only once.

> **See Also:** "JSON_TABLE Generalizes Other Oracle SQL Functions" on page 39-26

Oracle SQL Function JSON_VALUE

Oracle SQL function `json_value` selects a *scalar* value from JSON data and returns it as a SQL value. You can also use `json_value` to create function-based B-tree indexes for use with JSON data—see "Indexes for JSON Data" on page 39-31.

Function `json_value` has two required arguments and accepts optional returning and error clauses.

The first argument to `json_value` is a SQL expression that returns an instance of a scalar SQL data type (that is, not an object or collection data type). It can be of data type `VARCHAR2`, `BLOB`, or `CLOB`. It can be a table or view column value, a PL/SQL variable, or a bind variable with proper casting. The result of evaluating the SQL expression is used as the *context item* for evaluating the path expression.

The second argument to `json_value` is an Oracle JSON path expression followed by an optional `RETURNING` clause and an optional error clause. The path expression must target a single scalar value, or else an error occurs.

Note that the *default* error-handling behavior is `NULL ON ERROR`, which means that no value is returned if an error occurs—an error is not raised. In particular, if the path expression targets a non-scalar value, such as an array, no error is raised, by default. To ensure that an error is raised, use `ERROR ON ERROR`.

Note: Each key in a given JSON object is not necessarily unique; the same key may be repeated. The streaming evaluation that Oracle Database employs always uses only one of the object members that have a given key; any other members with the same key are ignored. It is unspecified which of multiple such members is used.

See also "Unique Versus Duplicate Keys in JSON Objects" on page 39-17.

See Also:

- "RETURNING Clause for Oracle SQL Functions for JSON" on page 39-13
- "Error Clause for Oracle SQL Functions for JSON" on page 39-14
- *Oracle Database SQL Language Reference* for information about `json_value`

Using Oracle SQL Function JSON_VALUE With a Boolean JSON Value

JSON has the Boolean values `true` and `false`. Oracle SQL has no Boolean data type. When Oracle SQL function `json_value` evaluates an Oracle JSON path expression and the result is `true` or `false`, there are two ways to handle the result in SQL.

By default, the returned data type is a SQL string (`VARCHAR2`), meaning that the result is the string `'true'` or `'false'`. You can alternatively return the result as a SQL number, in which case the JSON value `true` is returned as the number `1`, and `false` is returned as `0`.

Example 39–7 illustrates this. The first query returns the string `'true'`; the second query returns the number `1`.

Example 39–7 JSON_VALUE: Two Ways to Return a JSON Boolean Value in SQL

```
SELECT json_value(po_document, '$.AllowPartialShipment')
 FROM j_purchaseorder;

SELECT json_value(po_document, '$.AllowPartialShipment' RETURNING NUMBER)
  FROM j_purchaseorder;
```

> **Note:** Although you can return a Boolean value as a number, a JSON search index will not be picked up for such a value. For this reason, Oracle recommends that you use the default return-value data type, `VARCHAR2`.

Oracle SQL Function JSON_VALUE Applied to a null JSON Value

Oracle SQL function `json_value` applied to JSON value `null` returns SQL `NULL`, not the SQL string `'null'`. This means, in particular, that you cannot use `json_value` to distinguish the JSON value `null` from the absence of a value; SQL `NULL` indicates both cases.

JSON_VALUE as JSON_TABLE

Oracle SQL function `json_value` can be viewed as a special case of function `json_table`. Example 39–8 illustrates the equivalence: the two `SELECT` statements have the same effect.

Example 39–8 JSON_VALUE Expressed Using JSON_TABLE

```
SELECT json_value(column, json_path RETURNING data_type error_hander ON ERROR)
  FROM table;

SELECT jt.column_alias
  FROM table,
       json_table(column, '$' error_handler ON ERROR
         COLUMNS ("COLUMN_ALIAS" data_type PATH json_path)) AS "JT";
```

In addition to perhaps helping you understand `json_value` better, this equivalence is important practically, because it means that you can use either function to get the same effect.

In particular, if you use `json_value` more than once, or you use it in combination with `json_exists` or `json_query` (which can also be expressed using `json_table`), to access the same data then it is typically more efficient to use a single invocation of `json_table` instead, because the data is parsed only once.

See Also: "JSON_TABLE Generalizes Other Oracle SQL Functions" on page 39-26

Oracle SQL Function JSON_QUERY

Oracle SQL function `json_query` selects one or more values from JSON data and returns a string (`VARCHAR2`) that represents the JSON values. (Unlike function `json_value`, the return data type cannot be `NUMBER`). You can thus use `json_query` to retrieve *fragments* of a JSON document.

The first argument to `json_query` is a SQL expression that returns an instance of a scalar SQL data type (that is, not an object or collection data type). It can be of data type `VARCHAR2`, `BLOB`, or `CLOB`. It can be a table or view column value, a PL/SQL variable, or a bind variable with proper casting. The result of evaluating the SQL expression is used as the *context item* for evaluating the path expression.

The second argument to `json_query` is an Oracle JSON path expression followed by an optional `RETURNING` clause, an optional wrapper clause, and an optional error clause. The path expression can target any number of JSON values.

In the `RETURNING` clause you can specify only data type `VARCHAR2`; you cannot specify `NUMBER`.

The wrapper clause determines the form of the returned string value.

Note that the error clause for `json_query` can specify `EMPTY ON ERROR`, which means that an empty array (`[]`) is returned in case of error (no error is raised).

Example 39–9 shows an example of the use of Oracle SQL function `json_query` with an array wrapper. For each document it returns a `VARCHAR2` value whose contents represent a JSON array with elements the phone types, in an unspecified order. For the document in Example 39–4 on page 39-15 the phone types are `"Office"` and `"Mobile"`, and the array returned is either `["Mobile", "Office"]` or `["Office", "Mobile"]`.

Example 39–9 Selecting JSON Values Using JSON_QUERY

```
SELECT json_query(po_document, '$.ShippingInstructions.Phone[*].type'
                               WITH WRAPPER)
  FROM j_purchaseorder;
```

Note that if path expression `$.ShippingInstructions.Phone.type` were used in Example 39–9 it would give the same result. Because of Oracle JSON path-expression syntax relaxation, `[*].type` is equivalent to `.type`.

See Also:

- *Oracle Database SQL Language Reference* for information about `json_query`
- "Oracle JSON Path Expression Syntax Relaxation" on page 39-10
- "RETURNING Clause for Oracle SQL Functions for JSON" on page 39-13
- "Wrapper Clause for Oracle SQL Functions JSON_QUERY and JSON_TABLE" on page 39-13
- "Error Clause for Oracle SQL Functions for JSON" on page 39-14

JSON_QUERY as JSON_TABLE

Oracle SQL function `json_query` can be viewed as a special case of function `json_table`. Example 39–10 illustrates the equivalence: the two `SELECT` statements have the same effect.

Example 39–10 JSON_QUERY Expressed Using JSON_TABLE

```
SELECT json_query(column, json_path
                  RETURNING data_type array_wrapper error_hander ON ERROR)
  FROM table;

SELECT jt.column_alias
  FROM table,
       json_table(column, '$' error_handler ON ERROR
         COLUMNS ("COLUMN_ALIAS" data_type FORMAT JSON array_wrapper
                  PATH json_path)) AS "JT";
```

In addition to perhaps helping you understand `json_query` better, this equivalence is important practically, because it means that you can use either function to get the same effect.

In particular, if you use `json_query` more than once, or you use it in combination with `json_exists` or `json_value` (which can also be expressed using `json_table`), to access the same data then it is typically more efficient to use a single invocation of `json_table` instead, because the data is parsed only once.

> **See Also:** "JSON_TABLE Generalizes Other Oracle SQL Functions" on page 39-26

Oracle SQL Function JSON_TABLE

Oracle SQL function `json_table` projects JSON data into a relational format. You use `json_table` to decompose the result of JSON expression evaluation into the relational rows and columns of a new, virtual table, which you can also think of as an inline relational view. You can then insert this virtual table into a pre-existing database table, or you can query it using SQL—in a join expression, for example.

In particular, a common use of `json_table` is to create a relational view of JSON data. You can use such a view just as you would use any relational table or view. This lets applications, tools, and programmers operate on JSON data as if it were relational, that is, without consideration of the syntax of JSON or JSON path expressions.

Defining a relational view over JSON data in effect maps a kind of *schema* onto that data. This mapping is *after the fact*: the underlying JSON data can be defined and created without any regard to a schema or any particular pattern of use. Data first, schema later.

Such a schema (mapping) imposes no restriction on the kind of JSON documents that can be stored in the underlying table (other than being well-formed JSON data). The relational view exposes only data that conforms to the mapping (schema) that defines the view. To change the schema, just redefine the view—no need to reorganize the underlying JSON data. Example 39–17 on page 39-29 illustrates the creation of a relational view using `json_table`.

You use `json_table` in a SQL `FROM` clause. It is thus a **row source**: it generates a row of relational data for each JSON value selected by a *row path expression* (row pattern).

The rows created by a `json_table` invocation are laterally joined, implicitly, to the row that generated them. That is, you need not explicitly join the virtual table produced by `json_table` with the table that contains the JSON data.

The first argument to `json_table` is a SQL expression that returns an instance of a scalar SQL data type (that is, not an object or collection data type). It can be of data type `VARCHAR2`, `BLOB`, or `CLOB`. It can be a table or view column value, a PL/SQL variable, or a bind variable with proper casting. The result of evaluating the SQL expression is used as the *context item* for evaluating the row path expression.

The second argument to `json_table` is an Oracle JSON row path expression followed by an optional error clause for handling the row and a (required) `COLUMNS` clause. (There is no `RETURNING` clause.) The path expression can target any number of JSON values.

The row path expression acts as a pattern for the rows of the generated virtual table. It is matched against the context item provided by the SQL `FROM` clause, producing rows of SQL data that are organized into relational columns, which you specify in the `COLUMNS` clause. Each of those rows is matched against zero or more *column path expressions* to generate the relational columns of the virtual table.

There are two levels of error handling for `json_table`, corresponding to the two levels of path expressions: row and column. When present, a column error handler overrides row-level error handling. The default error handler for both levels is `NULL ON ERROR`.

The mandatory `COLUMNS` clause defines the columns of the virtual table to be created by `json_table`. It consists of the keyword **`COLUMNS`** followed by the following entries enclosed in parentheses:

- At most one entry in the `COLUMNS` clause can be a column name followed by the keywords **`FOR ORDINALITY`**, which specifies a column of generated row numbers (SQL data type `NUMBER`). These numbers start with one.
- Other than the optional `FOR ORDINALITY` entry, each entry in the `COLUMNS` clause is either a regular column specification or a nested columns specification.
- A *regular column* specification consists of a column name followed by an optional scalar data type for the column, which can be SQL data type `VARCHAR2` or `NUMBER` (the same as for the `RETURNING` clause of other Oracle SQL functions for JSON), followed by an optional value clause and a mandatory `PATH` clause. The default data type is `VARCHAR2(4000)`.
- A *nested columns* specification consists of the keyword **`NESTED`** followed by an optional `PATH` keyword, an Oracle JSON row path expression, and then a `COLUMNS` clause. This `COLUMNS` clause specifies columns that represent nested data. The row path expression used here provides a refined context for the specified nested columns: each nested column path expression is relative to the row path expression.

  A `COLUMNS` clause at any level (nested or not) has the same characteristics. In other words, `COLUMNS` clause is defined recursively. For each level of nesting (that is, for each use of keyword `NESTED`), the nested `COLUMNS` clause is said to be the **child** of the `COLUMNS` clause within which it is nested, which is its **parent**. Two or more `COLUMNS` clauses that have the same parent clause are **siblings**.

  The virtual tables defined by parent and child `COLUMNS` clauses are joined using an *outer* join, with the parent being the outer table. The virtual columns defined by sibling `COLUMNS` clauses are joined using a `union` join.

  Example 39–16 on page 39-28 illustrates the use of a nested columns clause.
- The optional value clause specifies how to handle the data projected to the column: whether to handle it as would `json_value`, `json_exists`, or `json_query`. This value handling includes the return data type, return format (pretty or ascii), wrapper, and error treatment.

By default, the projected data is handled as if by `json_value`. If you use keyword **`EXISTS`** then it is handled as if by `json_exists`. If you use keywords **`FORMAT JSON`** then it is handled as if by `json_query`.

For `FORMAT JSON` you can override the default wrapping behavior by adding an explicit wrapper clause.

You can override the default error handling for the given handler (`json_value`, `json_exists`, or `json_query`) by adding an explicit `ERROR` clause appropriate for it.

- The mandatory **`PATH`** clause specifies the portion of the row that is to be used as the column content. The column path expression following keyword `PATH` is matched against the context item provided by the virtual row. The column path expression must represent a *relative* path; it is relative to the path specified by the row path expression.

See Also:

- "RETURNING Clause for Oracle SQL Functions for JSON" on page 39-13
- "Wrapper Clause for Oracle SQL Functions JSON_QUERY and JSON_TABLE" on page 39-13
- "Error Clause for Oracle SQL Functions for JSON" on page 39-14
- *Oracle Database SQL Language Reference* for information about `json_table`

JSON_TABLE Generalizes Other Oracle SQL Functions

Oracle SQL function `json_table` generalizes functions `json_value`, `json_exists`, and `json_query`. Everything that you can do using these functions you can do using `json_table`. For the jobs that they do, the syntax of these functions is simpler to use than is the syntax of `json_table`.

However, be aware that if you use such functions to access the same input data, that data is parsed once for each use of one of the functions. It can be more efficient for such multiple accesses of the same data to use `json_table` instead, so the data is parsed only once.

Example 39–11 and Example 39–12 illustrate this. They each select the requestor and the set of phones used by each object in column `j_purchaseorder.po_document`. But Example 39–12 parses that column only once, not four times.

Example 39–11 Accessing JSON Data Multiple Times To Extract Data

```
SELECT json_value(po_document, '$.Requestor' RETURNING VARCHAR2(32)),
       json_query(po_document, '$.ShippingInstructions.Phone'
                               RETURNING VARCHAR2(100))
  FROM j_purchaseorder
  WHERE json_exists(po_document, '$.ShippingInstructions.Address.zipCode')
    AND json_value(po_document,  '$.AllowPartialShipment' RETURNING NUMBER(1))
        = 0;
```

Example 39–12 Using JSON_TABLE to Extract Data Without Multiple Parses

```
SELECT jt.requestor, jt.phones
  FROM j_purchaseorder,
       json_table(po_document, '$'
         COLUMNS (requestor VARCHAR2(32 CHAR) PATH '$.Requestor',
                  phones    VARCHAR2(100 CHAR) FORMAT JSON
```

```
                        PATH '$.ShippingInstructions.Phone',
                partial NUMBER(1) PATH '$.AllowPartialShipment',
                has_zip VARCHAR2(5 CHAR) EXISTS
                        PATH '$.ShippingInstructions.Address.zipCode')) jt
  WHERE jt.partial = 0 AND has_zip = 'true';
```

Note the following in connection with Example 39–12:

- A JSON value of `null` is a value as far as SQL is concerned; it is not `NULL`, which in SQL represents the absence of a value (missing, unknown, or inapplicable data). In Example 39–12, if the JSON value of object attribute `zipCode` is `null` then the SQL string `'true'` is returned.
- Although `json_exists` returns a Boolean value, as a SQL value this is represented by the SQL string `'true'` or `'false'`. If `json_exists` is used directly as a condition in a SQL `WHERE` clause or `CASE` statement then you need not test this return value explicitly; you can simply write `json_exists(...)`. But if `json_exists` is used elsewhere, to obtain a *value*, then the only way to test that value is as an explicit string. That is the case in Example 39–12: the value is stored in column `jt.has_zip`, and it is then tested explicitly for equality against the SQL string `'true'`.
- The JSON object attribute `AllowPartialShipment` has a JSON Boolean value. When `json_value` is applied to that value it can be returned as either a string or a number. In Example 39–12 the *implicit* use of `json_value` returns the value as data type `NUMBER`, and this value is then tested for equality against the number `1`.

Using JSON_TABLE with JSON Arrays

A JSON value can be an array or can include one or more arrays, nested to any number of levels inside other JSON arrays or objects.

Example 39–13 projects the requestor and associated phone numbers from the JSON data in column `po_document`. The entire JSON array `Phone` is projected as a relational column of JSON data, `ph_arr`. To format this JSON data as a `VARCHAR2` column, the keywords `FORMAT JSON` are needed.

Example 39–13 Projecting an Entire JSON Array as JSON Data

```
SELECT jt.*
  FROM j_purchaseorder,
       json_table(po_document, '$'
         COLUMNS (requestor VARCHAR2(32 CHAR) PATH '$.Requestor',
                  ph_arr    VARCHAR2(100 CHAR) FORMAT JSON
                            PATH '$.ShippingInstructions.Phone')) AS "JT";
```

What if you wanted to project the individual *elements* of JSON array `Phone` and not the array as a whole? Example 39–14 shows one way to do this, which you can use if the array elements are the only data you need to project.

Example 39–14 Projecting Elements of a JSON Array

```
SELECT jt.*
  FROM j_purchaseorder,
       json_table(po_document, '$.ShippingInstructions.Phone[*]'
         COLUMNS (phone_type VARCHAR2(10) PATH '$.type',
                  phone_num  VARCHAR2(20) PATH '$.number')) AS "JT";

PHONE_TYPE     PHONE_NUM
----------     ---------
Office         909-555-7307
```

```
Mobile         415-555-1234
```

If you want to project both the requestor and the corresponding phone data then the row path expression of Example 39–14 (`$.Phone[*]`) is not appropriate: it targets only the (phone object) elements of array `Phone`.

Example 39–15 shows one way to target both: use a *row path expression* that targets both the name and the entire phones array, and use *column path expressions* that target properties `type` and `number` of individual phone objects.

Example 39–15 Projecting Elements of a JSON Array Plus Other Data

```
SELECT jt.*
  FROM j_purchaseorder,
       json_table(po_document, '$'
         COLUMNS (
           requestor  VARCHAR2(32 CHAR) PATH '$.Requestor',
           phone_type VARCHAR2(50 CHAR) FORMAT JSON WITH WRAPPER
                      PATH '$.ShippingInstructions.Phone[*].type',
           phone_num  VARCHAR2(50 CHAR) FORMAT JSON WITH WRAPPER
                      PATH '$.ShippingInstructions.Phone[*].number')) AS "JT";

REQUESTOR    PHONE_TYPE            PHONE_NUM
---------    ----------            ---------
Alexis Bull  ["Office", "Mobile"]  ["909-555-7307", "415-555-1234"]
```

In Example 39–15 as in Example 39–13, keywords `FORMAT JSON` are needed because the resulting `VARCHAR2` columns contain JSON data, namely arrays of phone types or phone numbers, with one array element for each phone. In addition, unlike the case for Example 39–13, a wrapper clause is needed for column `phone_type` and column `phone_num`, because array `Phone` contains multiple objects with properties `type` and `number`.

The effect of Example 39–15 might not be what you want in some cases. For example, you might want a relational column that contains a single phone number (one row per number), rather than one that contains a JSON array of phone numbers (one row for all numbers for a given purchase order).

For that you need to tell `json_table` to project the array elements, by using a `json_table` **`NESTED`** path clause for the array. A `NESTED` path clause acts, in effect, as an additional row source (row pattern). Example 39–16 illustrates this.

Example 39–16 JSON_TABLE: Projecting Array Elements Using NESTED

```
SELECT jt.*
  FROM j_purchaseorder,
       json_table(po_document, '$'
         COLUMNS (
           requestor VARCHAR2(32 CHAR) PATH '$.Requestor',
           NESTED                      PATH '$.ShippingInstructions.Phone[*]'
             COLUMNS (phone_type VARCHAR2(32 CHAR) PATH '$.type',
                      phone_num  VARCHAR2(20 CHAR) PATH '$.number'))) AS "JT";
```

You can use any number of `NESTED` keywords in a given `json_table` invocation.

In Example 39–16 the outer `COLUMNS` clause is the parent of the nested (inner) `COLUMNS` clause. The virtual tables defined are joined using an outer join, with the table defined by the parent clause being the outer table in the join.

(If there were a second columns clause nested directly under the same parent, the two nested clauses would be sibling `COLUMNS` clauses.)

Example 39–17 defines a relational view over JSON data. It uses a `NESTED` path clause to project the elements of array `LineItems`.

Example 39–17 Defining a Relational View Over JSON Data

```
CREATE OR REPLACE VIEW j_purchaseorder_detail_view AS
  SELECT d.*
    FROM j_purchaseorder po,
         json_table(po.po_document, '$'
           COLUMNS (
             po_number        NUMBER(10)         PATH '$.PONumber',
             reference        VARCHAR2(30 CHAR)  PATH '$.Reference',
             requestor        VARCHAR2(128 CHAR) PATH '$.Requestor',
             userid           VARCHAR2(10 CHAR)  PATH '$.User',
             costcenter       VARCHAR2(16)       PATH '$.CostCenter',
             ship_to_name     VARCHAR2(20 CHAR)
                              PATH '$.ShippingInstructions.name',
             ship_to_street   VARCHAR2(32 CHAR)
                              PATH '$.ShippingInstructions.Address.street',
             ship_to_city     VARCHAR2(32 CHAR)
                              PATH '$.ShippingInstructions.Address.city',
             ship_to_county   VARCHAR2(32 CHAR)
                              PATH '$.ShippingInstructions.Address.county',
             ship_to_postcode VARCHAR2(10 CHAR)
                              PATH '$.ShippingInstructions.Address.postcode',
             ship_to_state    VARCHAR2(2 CHAR)
                              PATH '$.ShippingInstructions.Address.state',
             ship_to_zip      VARCHAR2(8 CHAR)
                              PATH '$.ShippingInstructions.Address.zipCode',
             ship_to_country  VARCHAR2(32 CHAR)
                              PATH '$.ShippingInstructions.Address.country',
             ship_to_phone    VARCHAR2(24 CHAR)
                              PATH '$.ShippingInstructions.Phone[0].number',
             NESTED PATH '$.LineItems[*]'
               COLUMNS (
                 itemno      NUMBER(38)         PATH '$.ItemNumber',
                 description VARCHAR2(256 CHAR) PATH '$.Part.Description',
                 upc_code    VARCHAR2(14 CHAR)  PATH '$.Part.UPCCode',
                 quantity    NUMBER(12,4)       PATH '$.Quantity',
                 unitprice   NUMBER(14,2)       PATH '$.Part.UnitPrice'))) d;
```

Simple Dot-Notation Access to JSON Data

Oracle SQL functions `json_query` and `json_value` accept an Oracle JSON path expression as argument and match it against the target JSON data. These functions accept optional returning, wrapper, and error handling clauses, to specify the following, respectively: the data type of the return value, whether or not to wrap multiple values as an array, and how to handle errors.

As an alternative for simple use cases, you can use a dot-notation syntax to query JSON data without using `json_query` or `json_value`. This section describes this feature.

The behavior of a query using the dot notation is different from both `json_query` and `json_value`. In effect, it combines their behavior to return one or more JSON values whenever possible.

Where one or the other of these SQL functions might return `NULL` or raise an error because the path expression does not match the JSON data, a dot-notation query often

returns a useful JSON value. The return value is always a string (data type `VARCHAR2`) representing JSON data. The content of the string depends on the targeted JSON data, as follows:

- If a *single* JSON value is targeted, then that value is the string content, whether it is a JSON scalar, object, or array.
- If *multiple* JSON values are targeted, then the string content is a JSON array whose elements are those values.

In the first case, the behavior is similar to that of `json_value` for a *scalar* value, and it is similar to that of `json_query` for an *object* or *array* value.

In the second case, the behavior is similar to that of `json_query` with an array wrapper.

The dot-notation *syntax* is a table alias followed by a dot (`.`), the name of a JSON column, and one or more pairs of the form `.` *`json_object_key`*. (Note that the table alias is mandatory.)

Each *`json_object_key`* must be a valid SQL identifier, and the column must have an `is json` check constraint, which ensures that it contains well-formed JSON data. If either of these rules is not respected then an error is raised at query compile time. (The check constraint must be present to avoid raising an error; however, it need not be active. If you deactivate the constraint then this error is not raised.)

For this JSON dot notation, unlike the case generally for SQL, unquoted identifiers (after the column name) are treated *case sensitively*, that is, just as if they were quoted. This is a convenience: you can use JSON object keys as identifiers here without quoting them. For example, you can write just `jcolumn.friends` instead of `jcolumn."friends"`. And if a JSON object is named using uppercase, such as `FRIENDS`, then you must write `jcolumn.FRIENDS`, not `jcolumn.friends`.

Note: Each component of the dot-notation syntax is limited to a maximum of 30 bytes. See *Oracle Database SQL Language Reference* for more information about the dot-notation syntax and SQL identifiers.

Matching of a JSON dot-notation expression against JSON data is the same as for an Oracle JSON path expression, including the relaxation to allow implied array iteration (see "Oracle JSON Path Expression Syntax Relaxation" on page 39-10). The JSON column of a dot-notation expression corresponds to the context item of a path expression, and each identifier used in the dot notation corresponds to an identifier used in a path expression.

For example, if JSON column `jcolumn` corresponds to the path-expression context item, then dot-notation expression `jcolumn.friends` corresponds to path expression `$.friends`, and `jcolumn.friends.name` corresponds to `$.friends.name`.

For the latter, the context item can be an object or an array of objects. If it is an array of objects then each of the objects is matched for a property `friends`. The value of property `friends` can itself be an object or an array of objects. In the latter case, the first object in the array is used.

Other than the implied use of a wildcard for array elements (see "Oracle JSON Path Expression Syntax Relaxation" on page 39-10), a path expression with wildcards *cannot* be expressed using the dot-notation syntax. Dot-notation syntax is a handy alternative to using simple path expressions; it is not a replacement for using path expressions in general.

Example 39–18 shows equivalent dot-notation and `json_value` queries. Given the data from Example 39–4 on page 39-15, each of the queries returns the string `"1600"`, a `VARCHAR2` value representing the JSON number `1600`.

Example 39–18 JSON Dot-Notation Query Compared with JSON_VALUE

```
SELECT po.po_document.PONumber FROM j_purchaseorder po;

SELECT json_value(po_document, '$.PONumber') FROM j_purchaseorder;
```

Example 39–19 shows equivalent dot-notation and `json_query` queries. Each query in the first pair returns (a `VARCHAR2` value representing) a JSON array of phone objects. Each query in the second pair returns (a `VARCHAR2` value representing) an array of phone types, just as in Example 39–9 on page 39-23.

Example 39–19 JSON Dot-Notation Query Compared with JSON_QUERY

```
SELECT po.po_document.ShippingInstructions.Phone FROM j_purchaseorder po;

SELECT json_query(po_document, '$.ShippingInstructions.Phone')
  FROM j_purchaseorder;

SELECT po.po_document.ShippingInstructions.Phone.type FROM j_purchaseorder po;

SELECT json_query(po_document, '$.ShippingInstructions.Phone.type' WITH WRAPPER)
  FROM j_purchaseorder;
```

See Also:

- *Oracle Database SQL Language Reference* for information about dot notation used for SQL object and object attribute access (object access expressions)
- "Oracle JSON Path Expressions" on page 39-8
- "Using a Check Constraint To Ensure that a Column Contains JSON Data" on page 39-15
- "Oracle SQL Functions and Conditions for Use with JSON Data" on page 39-12

Indexes for JSON Data

There is no dedicated SQL data type for JSON data. You can index JSON data as you would any data of the type you use to store it. This means, in particular, that you can use a B-tree index or a bitmap index for Oracle SQL function `json_value`, and you can use a bitmap index for Oracle SQL conditions `is json`, `is not json`, and `json_exists`.

(More generally, a bitmap index can be appropriate wherever the number of possible values for the function is small. For example, you can use a bitmap index for function `json_value` if the value is expected to be Boolean or otherwise one of a small number of string values.)

As always, such function-based indexing is appropriate for queries that target particular functions, which in the context of Oracle SQL functions for JSON means particular *path expressions*. It is not very helpful for queries that are ad hoc, that is, arbitrary. Define a function-based index if you know that you will often query a particular JSON path expression.

If you query in an ad hoc manner then define a **JSON search index**. This is a general index, *not targeted* to any specific JSON path expression. It is appropriate for *structural* queries, such as looking for the third element of an array value of a particular object property, and for *full-text* queries using Oracle SQL condition `json_textcontains`, such as looking for a particular word among various string values.

You can of course define both function-based indexes and a JSON search index for the same JSON column.

A JSON search index is an Oracle Text (full-text) index designed specifically for use with JSON data.

> **See Also:** "Full-Text Search of JSON Data" on page 39-36 for information about creating and using a JSON search index

How To Tell Whether a Function-Based Index for JSON Data Is Picked Up

To determine whether a given query picks up a given function-based index, look for the index name in the execution plan for the query. For example, given the index defined in Example 39–22, an execution plan for the `json_value` query of Example 39–18 references an index scan with index `po_num_id1`.

Creating Bitmap Indexes for Oracle SQL Condition JSON_EXISTS

Example 39–20 creates a bitmap index for the value returned by `json_exists`. This is the right kind of index to use because there are only two possible return values for a condition (true and false).

Example 39–20 Creating a Bitmap Index for JSON_EXISTS

```
CREATE BITMAP INDEX has_zipcode_idx
  ON j_purchaseorder (json_exists(po_document,
                                  '$.ShippingInstructions.Address.zipCode'));
```

Example 39–21 creates a bitmap index for a value returned by `json_value`. This is an appropriate index to use *if* there are only few possible values for property `CostCenter` in your data.

Example 39–21 Creating a Bitmap Index for JSON_VALUE

```
CREATE BITMAP INDEX cost_ctr_idx
  ON j_purchaseorder (json_value(po_document, '$.CostCenter'));
```

Creating JSON_VALUE Function-Based Indexes

Example 39–22 creates a function-based index for SQL function `json_value` on property `PONumber` of the object that is in column `po_document` of table `j_purchaseorder`. The object is passed as the path-expression context item.

Example 39–22 Creating a Function-Based Index for a JSON Object Property: JSON_VALUE

```
CREATE UNIQUE INDEX po_num_idx1
  ON j_purchaseorder (json_value(po_document, '$.PONumber'
                                 RETURNING NUMBER ERROR ON ERROR));
```

The use of `ERROR ON ERROR` here means that if the data contains a record that either has *no* `PONumber` property or has a `PONumber` property with a *non-number* value then index creation fails. And if the index exists then trying to insert such a record fails.

An alternative is to create an index using the simplified syntax described in "Simple Dot-Notation Access to JSON Data" on page 39-29. Example 39–23 illustrates this; it indexes both scalar and non-scalar results, corresponding to what a dot-notation query can return.

Example 39–23 Creating a Function-Based Index for a JSON Object Property: Dot Notation

```
CREATE UNIQUE INDEX po_num_idx2 ON j_purchaseorder po (po.po_document.PONumber);
```

The indexes created in both Example 39–22 and Example 39–23 can be picked up for either a query that uses dot-notation syntax or a query that uses `json_value`.

If the index of Example 39–23 is picked up for a `json_value` query then filtering is applied after index pickup, to test for the correct property value. Non-scalar values can be stored in this index, since dot-notation queries can return such values, but a `json_value` query cannot, so such values are filtered out after index pickup.

Oracle recommends that you create a function-based index for `json_value` using one of these forms:

- A `json_value` expression that specifies a **`RETURNING`** data type and uses **`ERROR ON ERROR`**.

  The indexed values are only (non-`null`) scalar values of the specified data type. The index can nevertheless be used in dot-notation queries that lead to such a scalar result.

- Dot-notation syntax

  The indexed values correspond to the flexible behavior of dot-notation queries, which return JSON values whenever possible. They can include non-scalar JSON values (JSON objects and arrays). They can match dot-notation queries in addition to `json_value` queries. The index is used to come up with an initial set of matches, which are then filtered according to the specifics of the query. For example, any indexed values that are not JSON scalars are filtered out.

Indexes created in both of these ways can thus be used with both dot-notation queries and `json_value` queries.

Using a JSON_VALUE Function-Based Index with JSON_TABLE Queries

An index created using `json_value` with `ERROR ON ERROR` can be used for a query involving `json_table`, if the `WHERE` clause refers to a column projected by `json_table` and the effective JSON path that targets that column matches the indexed path expression. The index acts as a constraint on the indexed path, to ensure that only one (non-`null`) scalar JSON value is projected for each item in the JSON collection.

The query in Example 39–24 thus makes use of the index created in Example 39–22.

Example 39–24 Use of a JSON_VALUE Function-Based Index with a JSON_TABLE Query

```
SELECT jt.*
  FROM j_purchaseorder po,
       json_table(po.po_document, '$'
         COLUMNS po_number  NUMBER(5) PATH '$.PONumber',
                 reference  VARCHAR2(30 CHAR) PATH '$.Reference',
```

```
                requestor  VARCHAR2(32 CHAR) PATH '$.Requestor',
                userid     VARCHAR2(10 CHAR) PATH '$.User',
                costcenter VARCHAR2(16 CHAR) PATH '$.CostCenter') jt
WHERE po_number = 1600;
```

Note: A function-based index created using a `json_value` expression or dot notation can be picked up for a correponding occurrence in a query `WHERE` clause only if the occurrence is used in a SQL *comparison* condition, such as `>=`. In particular, it is not picked up for an occurrence used in condition `IS NULL` or `IS NOT NULL`.

See *Oracle Database SQL Language Reference* for information about SQL comparison conditions.

Data Type Considerations for JSON_VALUE Indexing and Querying

By default, the Oracle SQL functions for JSON return a `VARCHAR2` value. When you create a function-based index using `json_value`, unless you use a `RETURNING` clause to specify a different return data type, the index is not picked up for a query that expects a non-`VARCHAR2` value.

For example, in the query of Example 39–25, `json_value` uses `RETURNING NUMBER`. The index created in Example 39–22 can be picked up for this query, because the indexed `json_value` expression specifies a return type of `NUMBER`.

Example 39–25 JSON_VALUE Query with Explicit RETURNING NUMBER

```
SELECT count(*) FROM j_purchaseorder po
  WHERE json_value(po_document, '$.PONumber' RETURNING NUMBER) > 1500;
```

But the index created in Example 39–23 does not use `RETURNING NUMBER` (the return type is `VARCHAR2(4000)`, by default), so it cannot be picked up for a such a query.

Now consider the queries in Example 39–26 and Example 39–27, which use `json_value` without a `RETURNING` clause, so that the value returned is of type `VARCHAR2`.

Example 39–26 JSON_VALUE Query with Explicit Numerical Conversion

```
SELECT count(*) FROM j_purchaseorder po
  WHERE to_number(json_value(po_document, '$.PONumber')) > 1500;
```

Example 39–27 JSON_VALUE Query with Implicit Numerical Conversion

```
SELECT count(*) FROM j_purchaseorder po
  WHERE json_value(po_document, '$.PONumber') > 1500;
```

In Example 39–26, SQL function `to_number` explicitly converts the `VARCHAR2` value returned by `json_value` to a number. Similarly, in Example 39–27, comparison condition > (greater-than) implicitly converts the value to a number.

Neither of the indexes of Example 39–22 and Example 39–23 is picked up for either of these queries. The queries might return the right results in each case, because of type-casting, but the indexes cannot be used to evaluate the queries.

Consider also what happens if some of the data cannot be converted to a particular data type. For example, given the queries in Example 39–25, Example 39–26, and Example 39–27, what happens to a `PONumber` value such as `"alpha"`?

For Example 39–26 and Example 39–27, the query stops in error because of the attempt to cast the value to a number. For Example 39–25, however, because the default error handling behavior is `NULL ON ERROR`, the non-number value `"alpha"` is simply filtered out. The value is indexed, but it is ignored for the query.

Similarly, if the query used, say, `DEFAULT '1000' ON ERROR`, that is, if it specified a numeric default value, then no error would be raised for the value `"alpha"`: the default value of `1000` would be used.

Indexing Multiple JSON Properties Using a Composite B-Tree Index

To index multiple properties of a JSON object you first create virtual columns for them. Then you create a composite B-tree index on the virtual columns. Example 39–28 and Example 39–29 illustrate this. Example 39–28 creates virtual columns `userid` and `costcenter` for JSON object properties `User` and `CostCenter`, respectively.

Example 39–28 Creating Virtual Columns for JSON Object Properties

```
ALTER TABLE j_purchaseorder ADD (userid VARCHAR2(20)
  GENERATED ALWAYS AS (json_value(po_document, '$.User' RETURNING VARCHAR2(20))));

ALTER TABLE j_purchaseorder ADD (costcenter VARCHAR2(6)
  GENERATED ALWAYS AS (json_value(po_document, '$.CostCenter'
                      RETURNING VARCHAR2(6))));
```

Example 39–29 creates a composite B-tree index on the virtual columns of Example 39–28.

Example 39–29 Creating a Composite B-tree Index for JSON Object Properties

```
CREATE INDEX user_cost_ctr_idx on j_purchaseorder(userid, costcenter);
```

A SQL query that references either the virtual columns or the corresponding JSON data (object properties) picks up the composite index. This is the case for both of the queries in Example 39–30.

Example 39–30 Two Ways to Query JSON Data Indexed with a Composite Index

```
SELECT po_document FROM j_purchaseorder WHERE userid      = 'ABULL'
                                          AND costcenter  = 'A50';

SELECT po_document
  FROM j_purchaseorder WHERE json_value(po_document, '$.User')       = 'ABULL'
                         AND json_value(po_document, '$.CostCenter') = 'A50';
```

These two queries have the same effect, including the same performance. However, the first query form does not target the JSON data itself; it targets the virtual columns that are used to index that data.

The data does not depend logically on any indexes implemented to improve query performance. If you want this independence from implementation to be reflected in your code, then use the second query form. Doing that ensures that the query behaves the same functionally with or without the index—the index serves only to improve performance.

Full-Text Search of JSON Data

You can use Oracle SQL condition **json_textcontains** in a CASE expression or the WHERE clause of a SELECT statement to perform a full-text search of JSON data that is stored in a VARCHAR2, BLOB, or CLOB column.

To be able to use condition json_textcontains, you first must create a JSON search index, which is an Oracle Text index designed specifically for use with JSON data. If you do not, then an error is raised when json_textcontains is used.

A JSON search index is appropriate for general, ad hoc queries of JSON data, whether or not those queries make use of full-text search.

Note: A JSON search index can only be used when the database character set is AL32UTF8 or WE8ISO8859P1, and only for JSON data that uses VARCHAR2, BLOB, or CLOB storage. Otherwise, the index can be created but it has no effect on queries.

You create a JSON search index by specifying an index type of CTXSYS.CONTEXT and section group **CTXSYS.JSON_SECTION_GROUP** using a PARAMETERS clause. Example 39–31 illustrates this.

Example 39–31 Creating a JSON Search Index

```
CREATE INDEX po_search_idx ON j_purchaseorder (po_document)
  INDEXTYPE IS CTXSYS.CONTEXT
  PARAMETERS ('section group CTXSYS.JSON_SECTION_GROUP SYNC (ON COMMIT)');
```

Example 39–32 shows a full-text query that finds purchase-order documents that contain the keyword Magic in any of the line-item part desciptions.

Example 39–32 Full-Text Query of JSON Data

```
SELECT po_document FROM j_purchaseorder
  WHERE json_textcontains(po_document, '$.LineItems.Part.Description', 'Magic');
```

Example 39–33 shows some *non* full-text queries of JSON data that also make use of the JSON search index created in Example 39–31.

Example 39–33 Ad Hoc Queries of JSON Data

```
SELECT po_document FROM j_purchaseorder
  WHERE json_exists(po_document, '$.ShippingInstructions.Address.country');

SELECT po_document FROM j_purchaseorder
  WHERE json_value(po_document, '$.User') = 'ABULL';
```

Note: When json_value is used, a JSON search index is used as a post-processing filter. The index can be picked up for json_value only if the return value is VARCHAR2, not NUMBER, and only for an equality comparison. For example, it is not picked up for a comparison such as json_value(column, '$.name_first') > 'Nimrod'.

If the name of your JSON search index is present in the execution plan for your query, then you know that the index was in fact picked up for that query. You will see a line similar to that shown in Example 39–34.

Example 39–34 Execution Plan Indication that a JSON Search Index Is Used

```
|* 2|   DOMAIN INDEX     | PO_SEARCH_IDX |     |     |     4 (0)
```

A JSON search index is maintained asynchronously, on demand. You can thus defer the cost of index maintenance, performing it at commit time only or at some time when database load is reduced. This can improve DML performance. It can also improve index maintenance performance by enabling bulk loading of unsynchronized index rows when an index is synchronized. On the other hand, asynchronous maintenance of an index means that until it is synchronized the index is not used for data that has been modified or newly inserted.

See Also:

- "Indexes for JSON Data" on page 39-31 for information about other ways to index JSON data
- *Oracle Database SQL Language Reference* for information about condition `json_textcontains`
- *Oracle Text Reference* for information about `CTXSYS.CONTEXT` indexes
- *Oracle Text Reference* for information about section group `CTXSYS.JSON_SECTION_GROUP`
- *Oracle Text Reference* for information about synchronizing a JSON search index

Loading External JSON Data

Example 39–3 and Example 39–4 create table `j_purchaseorder` and insert a single row of JSON data into it, for illustrative purposes. This section shows how you can create the full table from the data in JSON dump file `$ORACLE_HOME/demo/schema/order_entry/PurchaseOrders.dmp`. The format of this file is compatible with the export format produced by common NoSQL databases, including Oracle NoSQL Database. Each row of the file contains a single JSON document represented as a JSON object.

Example 39–35 creates a database directory that corresponds to file-system directory `$ORACLE_HOME/demo/schema/order_entry`. Example 39–37 then uses this database directory to create and fill an *external table*, `json_dump_file_contents`, with the data from the dump file, `PurchaseOrders.dmp`.

Example 39–35 Creating a Database Directory Object

```
CREATE OR REPLACE DIRECTORY order_entry_dir
  AS '$ORACLE_HOME/demo/schema/order_entry';
```

Example 39–36 Creating a Database Directory Object

```
CREATE OR REPLACE DIRECTORY loader_output_dir AS '/tmp';[5]
```

[5] This example uses a temporary file-system directory. On UNIX and Linux systems this would typically be `/tmp`. On MS Windows it would typically be folder temp, for example, `c:\temp`.

Example 39–37 Creating an External Table and Filling It from a JSON Dump File

```
CREATE TABLE json_dump_file_contents (json_document CLOB)
  ORGANIZATION EXTERNAL (TYPE ORACLE_LOADER DEFAULT DIRECTORY order_entry_dir
                         ACCESS PARAMETERS
                           (RECORDS DELIMITED BY 0x'0A'
                            DISABLE_DIRECTORY_LINK_CHECK
                            BADFILE loader_output_dir: 'JSONDumpFile.bad'
                            LOGFILE order_entry_dir: 'JSONDumpFile.log'
                            FIELDS (json_document CHAR(5000)))
                         LOCATION (order_entry_dir:'PurchaseOrders.dmp'))
  PARALLEL
  REJECT LIMIT UNLIMITED;
```

Example 39–38 copies the JSON documents from external table `json_dump_file_contents` to column `json_document` ?????? of relational table `j_purchaseorder`.

Example 39–38 Copying JSON Data from an External Table to a Relational Table

```
INSERT INTO j_purchaseorder
  SELECT SYS_GUID(), SYSTIMESTAMP, json_document FROM json_dump_file_contents
    WHERE json_document IS JSON;
```

See Also:

- *Oracle Database Concepts* for overview information about external tables
- *Oracle Database Utilities* for detailed information about external tables

Replication of JSON Data

You can replicate tables with columns containing JSON data using Oracle GoldenGate. Be aware that Oracle GoldenGate requires tables to be replicated to have a *nonvirtual* primary key column; the primary key column cannot be virtual.

All *indexes* on the JSON data will be replicated also. However, you must execute, on the replica database, any Oracle Text operations that you use to maintain a JSON search index. Here are examples of such procedures:

- `CTX_DDL.create_section_group`
- `CTX_DDL.drop_section_group`
- `CTX_DDL.set_sec_grp_attr`
- `CTX_DDL.sync_index`
- `CTX_DDL.optimize_index`

See Also: *Oracle GoldenGate* for information about Oracle GoldenGate

Oracle Database Support for JSON

This section describes Oracle Database support for JavaScript Object Notation (JSON).

This support is designed to provide the best fit between the worlds of relational storage and querying JSON data, allowing relational and JSON queries to work well together.

Note: Oracle is active in standardization efforts regarding SQL access to JSON data as part of a SQL/JSON standard. Oracle Database support for JSON will continue to track the development of such standards and evolve with it.

See Also:

- http://www.json.org and http://www.ecma-international.org

Part IX

Appendixes

Part IX of this manual provides background material as a set of appendixes:

- Appendix A, "Oracle-Supplied XML Schemas and Examples"
- Appendix B, "Oracle XML DB Restrictions"
- Appendix C, "Deprecated Functions for Updating XML Data"
- Appendix D, "Deprecated Constructs for XML Translation"
- Appendix E, "Full-Text Search over XML Data Without XQuery"

A

Oracle-Supplied XML Schemas and Examples

This appendix includes the definition and structure of `RESOURCE_VIEW` and `PATH_VIEW` and the Oracle XML DB-supplied XML schemas. It also includes a full listing of the purchase-order XML schemas used in various examples, and the C example for loading XML content into Oracle XML DB.

This appendix contains these topics:

XDBResource.xsd: XML Schema for Oracle XML DB Resources

Here is the complete listing for the Oracle XML DB supplied XML schema, `XDBResource.xsd`, which is used to represent Oracle XML DB resources.

XDBResource.xsd

```
<schema xdb:schemaURL="http://xmlns.oracle.com/xdb/XDBResource.xsd"
        targetNamespace="http://xmlns.oracle.com/xdb/XDBResource.xsd" version="1.0"
        xdb:numProps="73" elementFormDefault="qualified" xdb:flags="23"
        xdb:mapStringToNCHAR="false" xdb:mapUnboundedStringToLob="false"
        xdb:storeVarrayAsTable="false" xdb:schemaOwner="XDB"
        xmlns="http://www.w3.org/2001/XMLSchema" xmlns:xdb="http://xmlns.oracle.com/xdb"
        xmlns:xdbres="http://xmlns.oracle.com/xdb/XDBResource.xsd">
  <simpleType name="OracleUserName">
    <restriction base="string">
      <minLength value="1" fixed="false"/>
      <maxLength value="4000" fixed="false"/>
    </restriction>
  </simpleType>
  <simpleType name="ResMetaStr">
    <restriction base="string">
      <minLength value="1" fixed="false"/>
```

```
    <maxLength value="128" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="SchElemType">
  <restriction base="string">
    <minLength value="1" fixed="false"/>
    <maxLength value="4000" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="GUID">
  <restriction base="hexBinary">
    <minLength value="8" fixed="false"/>
    <maxLength value="32" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="LocksRaw">
  <restriction base="hexBinary">
    <minLength value="0" fixed="false"/>
    <maxLength value="2000" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="lockModeType">
  <restriction base="string">
    <enumeration value="exclusive" fixed="false"/>
    <enumeration value="shared" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="lockTypeType">
  <restriction base="string">
    <enumeration value="read-write" fixed="false"/>
    <enumeration value="write" fixed="false"/>
    <enumeration value="read" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="lockDepthType">
  <restriction base="string">
    <enumeration value="0" fixed="false"/>
    <enumeration value="infinity" fixed="false"/>
  </restriction>
</simpleType>
<complexType name="lockType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <element xdb:propNumber="768" name="LockOwner" type="string" xdb:memType="1"
             xdb:system="false" xdb:mutable="true" xdb:JavaType="String"
             xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="769" name="Mode" type="xdb:lockModeType" xdb:memType="1"
             xdb:system="false" xdb:mutable="true" xdb:JavaType="String"
             xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="770" name="Type" type="xdb:lockTypeType" xdb:memType="1"
             xdb:system="false" xdb:mutable="true" xdb:JavaType="String"
             xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="771" name="Depth" type="xdb:lockDepthType" xdb:memType="1"
             xdb:system="false" xdb:mutable="true" xdb:JavaType="String"
             xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
```

```
            xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
            xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="772" name="Expiry" type="dateTime" xdb:memType="180"
            xdb:system="false" xdb:mutable="true" xdb:JavaType="TimeStamp"
            xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
            xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
            xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <choice minOccurs="0" maxOccurs="unbounded">
     <element xdb:propNumber="773" name="Token" type="string" xdb:memType="1"
              xdb:system="false" xdb:mutable="true" xdb:JavaType="String"
              xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
              xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
              xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
     <element xdb:propNumber="774" name="NodeId" type="string" xdb:memType="1"
              xdb:system="false" xdb:mutable="true" xdb:JavaType="String"
              xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
              xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
              xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    </choice>
  </sequence>
</complexType>
<complexType name="locksType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <element xdb:propNumber="767" name="Lock" type="xdb:lockType" xdb:memType="258"
            xdb:system="false" xdb:mutable="true" xdb:JavaType="XMLType"
            xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
            xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
            xdb:defaultTableSchema="XDB" minOccurs="0" maxOccurs="2147483647"/>
  </sequence>
</complexType>
<complexType name="ResContentsType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <any xdb:propNumber="736" name="ContentsAny" xdb:memType="258" xdb:system="false"
         xdb:mutable="false" xdb:JavaType="XMLType" minOccurs="0" maxOccurs="1"/>
  </sequence>
</complexType>
<complexType name="ResAclType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <any xdb:propNumber="737" name="ACLAny" xdb:memType="258" xdb:system="false"
         xdb:mutable="false" xdb:JavaType="XMLType" minOccurs="0" maxOccurs="1"/>
  </sequence>
</complexType>
<complexType name="AttrCopyType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <any xdb:propNumber="748" name="AttrCopyAny" xdb:memType="258" xdb:system="false"
         xdb:mutable="false" xdb:JavaType="XMLType" minOccurs="0" maxOccurs="65535"/>
  </sequence>
</complexType>
<complexType name="RCListType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <element xdb:propNumber="755" name="OID" type="hexBinary" xdb:memByteLength="22"
            xdb:memType="23" xdb:system="false" xdb:mutable="false" xdb:SQLName="OID"
            xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
            xdb:SQLCollType="XDB$OID_LIST_T" xdb:SQLCollSchema="XDB" xdb:hidden="false"
            nillable="false" abstract="false" xdb:SQLInline="true"
            xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
            xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1"
            maxOccurs="65535"/>
  </sequence>
</complexType>
```

```
<complexType name="ResourceType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <element xdb:propNumber="709" name="CreationDate" type="dateTime" xdb:memType="180"
             xdb:system="false" xdb:mutable="false" xdb:SQLName="CREATIONDATE"
             xdb:SQLType="TIMESTAMP" xdb:JavaType="TimeStamp" xdb:global="false"
             nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="710" name="ModificationDate" type="dateTime"
             xdb:memType="180" xdb:system="false" xdb:mutable="false"
             xdb:SQLName="MODIFICATIONDATE" xdb:SQLType="TIMESTAMP"
             xdb:JavaType="TimeStamp" xdb:global="false" nillable="false"
             abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
             xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
             xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="711" name="Author" type="xdb:ResMetaStr" xdb:memType="1"
             xdb:system="false" xdb:mutable="false" xdb:SQLName="AUTHOR"
             xdb:SQLType="VARCHAR2" xdb:JavaType="String" xdb:global="false"
             nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="712" name="DisplayName" type="xdb:ResMetaStr"
             xdb:memType="1" xdb:system="false" xdb:mutable="false"
             xdb:SQLName="DISPNAME" xdb:SQLType="VARCHAR2" xdb:JavaType="String"
             xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="713" name="Comment" type="xdb:ResMetaStr" xdb:memType="1"
             xdb:system="false" xdb:mutable="false" xdb:SQLName="RESCOMMENT"
             xdb:SQLType="VARCHAR2" xdb:JavaType="String" xdb:global="false"
             nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="714" name="Language" type="xdb:ResMetaStr" xdb:memType="1"
             xdb:system="false" xdb:mutable="false" xdb:SQLName="LANGUAGE"
             xdb:SQLType="VARCHAR2" xdb:JavaType="String" default="en"
             xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="715" name="CharacterSet" type="xdb:ResMetaStr"
             xdb:memType="1" xdb:system="false" xdb:mutable="false"
             xdb:SQLName="CHARSET" xdb:SQLType="VARCHAR2" xdb:JavaType="String"
             xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="716" name="ContentType" type="xdb:ResMetaStr"
             xdb:memType="1" xdb:system="false" xdb:mutable="false"
             xdb:SQLName="CONTYPE" xdb:SQLType="VARCHAR2" xdb:JavaType="String"
             xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
             xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
             xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="717" name="RefCount" type="nonNegativeInteger"
             xdb:memByteLength="4" xdb:memType="68" xdb:system="false"
             xdb:mutable="true" xdb:SQLName="REFCOUNT" xdb:SQLType="RAW"
             xdb:JavaType="long" xdb:global="false" nillable="false" abstract="false"
             xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
             xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
             minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="718" name="LockBuf" type="xdb:LocksRaw" xdb:memType="23"
             xdb:system="false" xdb:mutable="true" xdb:SQLName="LOCKS" xdb:SQLType="RAW"
```

```
          xdb:JavaType="byteArray" xdb:global="false" nillable="false"
          abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
          xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
          xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="732" name="ACL" type="xdb:ResAclType" xdb:memType="258"
          xdb:system="false" xdb:mutable="false" xdb:JavaType="XMLType"
          xdb:global="false" xdb:hidden="false" xdb:transient="generated"
          xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
          xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
          xdb:defaultTableSchema="XDB" xdb:JavaClassname="oracle.xdb.ResAclTypeBean"
          xdb:beanClassname="oracle.xdb.ResAclTypeBean" xdb:numCols="0" minOccurs="0"
          maxOccurs="1"/>
    <element xdb:propNumber="719" name="ACLOID" type="hexBinary" xdb:memType="23"
          xdb:system="false" xdb:mutable="false" xdb:SQLName="ACLOID"
          xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
          xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
          xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
          xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
          minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="720" name="Owner" type="xdb:OracleUserName" xdb:memType="1"
          xdb:system="false" xdb:mutable="false" xdb:JavaType="String"
          xdb:global="false" xdb:hidden="false" xdb:transient="generated"
          xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
          xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
          xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="721" name="OwnerID" type="xdb:GUID" xdb:memType="23"
          xdb:system="false" xdb:mutable="false" xdb:SQLName="OWNERID"
          xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
          xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
          xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
          xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
          minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="722" name="Creator" type="xdb:OracleUserName"
          xdb:memType="1" xdb:system="false" xdb:mutable="false"
          xdb:JavaType="String" xdb:global="false" xdb:hidden="false"
          xdb:transient="generated" xdb:baseProp="false" nillable="false"
          abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
          xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
          xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="723" name="CreatorID" type="xdb:GUID" xdb:memType="23"
          xdb:system="false" xdb:mutable="false" xdb:SQLName="CREATORID"
          xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
          xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
          xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
          xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
          minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="724" name="LastModifier" type="xdb:OracleUserName"
          xdb:memType="1" xdb:system="false" xdb:mutable="false"
          xdb:JavaType="String" xdb:global="false" xdb:hidden="false"
          xdb:transient="generated" xdb:baseProp="false" nillable="false"
          abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
          xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
          xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="725" name="LastModifierID" type="xdb:GUID" xdb:memType="23"
          xdb:system="false" xdb:mutable="false" xdb:SQLName="LASTMODIFIERID"
          xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
          xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
          xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
          xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
          minOccurs="1" maxOccurs="1"/>
```

```
<element xdb:propNumber="726" name="SchemaElement" type="xdb:SchElemType"
         xdb:memType="1" xdb:system="false" xdb:mutable="false"
         xdb:JavaType="String" xdb:global="false" xdb:hidden="false"
         xdb:transient="generated" xdb:baseProp="false" nillable="false"
         abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
         xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
         xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="727" name="ElNum" type="nonNegativeInteger"
         xdb:memByteLength="4" xdb:memType="3" xdb:system="false"
         xdb:mutable="false" xdb:SQLName="ELNUM" xdb:SQLType="INTEGER"
         xdb:JavaType="long" xdb:global="false" xdb:hidden="true"
         xdb:baseProp="true" nillable="false" abstract="false" xdb:SQLInline="true"
         xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
         xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="728" name="SchOID" type="hexBinary" xdb:memType="23"
         xdb:system="false" xdb:mutable="false" xdb:SQLName="SCHOID"
         xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
         xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
         xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
         xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
         minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="733" name="Contents" type="xdb:ResContentsType"
         xdb:memType="258" xdb:system="false" xdb:mutable="false"
         xdb:JavaType="XMLType" xdb:global="false" xdb:hidden="false"
         xdb:transient="manifested" xdb:baseProp="false" nillable="false"
         abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
         xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
         xdb:JavaClassname="oracle.xdb.ResContentsTypeBean"
         xdb:beanClassname="oracle.xdb.ResContentsTypeBean" xdb:numCols="0"
         minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="729" name="XMLRef" type="REF" xdb:memType="110"
         xdb:system="false" xdb:mutable="true" xdb:SQLName="XMLREF"
         xdb:SQLType="REF" xdb:JavaType="Reference" xdb:global="false"
         xdb:hidden="true" xdb:baseProp="false" nillable="false" abstract="false"
         xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
         xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="0"
         minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="730" name="XMLLob" type="hexBinary" xdb:memType="113"
         xdb:system="false" xdb:mutable="true" xdb:SQLName="XMLLOB"
         xdb:SQLType="BLOB" xdb:JavaType="String" xdb:global="false"
         xdb:hidden="true" xdb:baseProp="false" nillable="false" abstract="false"
         xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
         xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="0"
         minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="731" name="Flags" type="nonNegativeInteger"
         xdb:memByteLength="4" xdb:memType="3" xdb:system="false" xdb:mutable="true"
         xdb:SQLName="FLAGS" xdb:SQLType="RAW" xdb:JavaType="long"
         xdb:global="false" xdb:hidden="true" xdb:baseProp="true" nillable="false"
         abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
         xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
         xdb:numCols="0" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="740" name="VCRUID" type="xdb:GUID" xdb:memType="23"
         xdb:system="false" xdb:mutable="false" xdb:SQLName="VCRUID"
         xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
         nillable="false" abstract="false" xdb:SQLInline="true"
         xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
         xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="741" name="Parents" type="hexBinary" xdb:memType="23"
         xdb:system="false" xdb:mutable="false" xdb:SQLName="PARENTS"
         xdb:SQLType="RAW" xdb:JavaType="Reference" xdb:global="false"
```

```
          xdb:SQLCollType="XDB$PREDECESSOR_LIST_T" xdb:SQLCollSchema="XDB"
          nillable="false" abstract="false" xdb:SQLInline="true"
          xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
          xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0"
          maxOccurs="1000"/>
  <element xdb:propNumber="745" name="SBResExtra" type="REF" xdb:memType="110"
          xdb:system="false" xdb:mutable="true" xdb:SQLName="SBRESEXTRA"
          xdb:SQLType="REF" xdb:JavaType="Reference" xdb:global="false"
          xdb:SQLCollType="XDB$XMLTYPE_REF_LIST_T" xdb:SQLCollSchema="XDB"
          xdb:hidden="true" xdb:baseProp="false" nillable="false" abstract="false"
          xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
          xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="0"
          minOccurs="0" maxOccurs="2147483647"/>
  <element xdb:propNumber="746" name="Snapshot" type="hexBinary" xdb:memType="23"
          xdb:system="false" xdb:mutable="true" xdb:SQLName="SNAPSHOT"
          xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
          xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
          xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
          xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="0"
          minOccurs="1" maxOccurs="1"/>
  <element xdb:propNumber="747" name="AttrCopy" type="xdb:AttrCopyType"
          xdb:memType="258" xdb:system="false" xdb:mutable="true"
          xdb:SQLName="ATTRCOPY" xdb:SQLType="BLOB" xdb:JavaType="XMLType"
          xdb:global="false" xdb:hidden="true" xdb:baseProp="true" nillable="false"
          abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
          xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
          xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
  <element xdb:propNumber="749" name="CtsCopy" type="hexBinary" xdb:memType="113"
          xdb:system="false" xdb:mutable="true" xdb:SQLName="CTSCOPY"
          xdb:SQLType="BLOB" xdb:JavaType="String" xdb:global="false"
          xdb:hidden="true" xdb:baseProp="false" nillable="false" abstract="false"
          xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
          xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
          minOccurs="0" maxOccurs="1"/>
  <element xdb:propNumber="750" name="NodeNum" type="hexBinary" xdb:memType="23"
          xdb:system="false" xdb:mutable="true" xdb:SQLName="NODENUM"
          xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
          xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
          xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
          xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="0"
          minOccurs="1" maxOccurs="1"/>
  <element xdb:propNumber="751" name="ContentSize" type="integer"
          xdb:memByteLength="8" xdb:memType="3" xdb:system="false"
          xdb:mutable="false" xdb:JavaType="long" xdb:global="false"
          xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"
          nillable="false" abstract="false" xdb:SQLInline="true"
          xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
          xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
  <element xdb:propNumber="752" name="SizeOnDisk" type="nonNegativeInteger"
          xdb:memByteLength="8" xdb:memType="3" xdb:system="false"
          xdb:mutable="false" xdb:SQLName="SIZEONDISK" xdb:SQLType="INTEGER"
          xdb:JavaType="long" xdb:global="false" xdb:hidden="true"
          xdb:baseProp="true" nillable="false" abstract="false" xdb:SQLInline="true"
          xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
          xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
  <element xdb:propNumber="754" name="RCList" type="xdb:RCListType" xdb:memType="258"
          xdb:system="false" xdb:mutable="false" xdb:SQLName="RCLIST"
          xdb:SQLType="XDB$RCLIST_T" xdb:SQLSchema="XDB" xdb:JavaType="XMLType"
          xdb:global="true" xdb:hidden="true" xdb:baseProp="true" nillable="false"
          abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
```

```
            xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTable="00"
            xdb:defaultTableSchema="XDB" xdb:JavaClassname="oracle.xdb.RCListBean"
            xdb:beanClassname="oracle.xdb.RCListBean" xdb:numCols="1" minOccurs="0"
            maxOccurs="1"/>
    <element xdb:propNumber="762" name="Branch" type="string" xdb:memType="1"
            xdb:system="false" xdb:mutable="false" xdb:SQLName="BRANCH"
            xdb:SQLType="VARCHAR2" xdb:JavaType="String" xdb:global="false"
            xdb:hidden="false" xdb:transient="generated" xdb:baseProp="false"
            nillable="false" abstract="false" xdb:SQLInline="true"
            xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
            xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="763" name="CheckedOutBy" type="xdb:OracleUserName"
            xdb:memType="1" xdb:system="false" xdb:mutable="false"
            xdb:JavaType="String" xdb:global="false" xdb:hidden="false"
            xdb:transient="generated" xdb:baseProp="false" nillable="false"
            abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
            xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
            xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="764" name="CheckedOutByID" type="xdb:GUID" xdb:memType="23"
            xdb:system="false" xdb:mutable="false" xdb:SQLName="CHECKEDOUTBYID"
            xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
            xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
            xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
            xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
            minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="765" name="BaseVersion" type="hexBinary" xdb:memType="23"
            xdb:system="false" xdb:mutable="false" xdb:SQLName="BASEVERSION"
            xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
            xdb:hidden="false" xdb:baseProp="false" nillable="false" abstract="false"
            xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
            xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1"
            minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="766" name="Locks" type="xdb:locksType" xdb:memType="258"
            xdb:system="false" xdb:mutable="true" xdb:JavaType="XMLType"
            xdb:global="false" xdb:hidden="true" xdb:transient="generated"
            nillable="false" abstract="false" xdb:SQLInline="true"
            xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
            xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <any xdb:propNumber="735" name="ResExtra" xdb:memType="258" xdb:system="false"
         xdb:mutable="false" xdb:SQLName="RESEXTRA" xdb:SQLType="CLOB"
         xdb:JavaType="XMLType" namespace="##other" minOccurs="0" maxOccurs="65535"/>
  </sequence>
  <attribute xdb:propNumber="705" name="Hidden" type="boolean" xdb:memByteLength="1"
            xdb:memType="252" xdb:system="false" xdb:mutable="false"
            xdb:JavaType="boolean" default="false" xdb:hidden="false"
            xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="706" name="Invalid" type="boolean" xdb:memByteLength="1"
            xdb:memType="252" xdb:system="false" xdb:mutable="false"
            xdb:JavaType="boolean" default="false" xdb:hidden="false"
            xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="707" name="VersionID" type="integer" xdb:memByteLength="4"
            xdb:memType="3" xdb:system="false" xdb:mutable="false"
            xdb:SQLName="VERSIONID" xdb:SQLType="INTEGER" xdb:JavaType="long"/>
  <attribute xdb:propNumber="708" name="ActivityID" type="integer" xdb:memByteLength="4"
            xdb:memType="3" xdb:system="false" xdb:mutable="false"
            xdb:SQLName="ACTIVITYID" xdb:SQLType="INTEGER" xdb:JavaType="long"/>
  <attribute xdb:propNumber="738" name="Container" type="boolean" xdb:memByteLength="1"
            xdb:memType="252" xdb:system="false" xdb:mutable="true"
            xdb:JavaType="boolean" default="false" xdb:hidden="false"
            xdb:transient="generated" xdb:baseProp="false"/>
```

```
  <attribute xdb:propNumber="739" name="CustomRslv" type="boolean" xdb:memByteLength="1"
             xdb:memType="252" xdb:system="false" xdb:mutable="false"
             xdb:JavaType="boolean" default="false" xdb:hidden="false"
             xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="742" name="VersionHistory" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="false" xdb:JavaType="boolean" default="false"
             xdb:hidden="false" xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="743" name="StickyRef" type="boolean" xdb:memByteLength="1"
             xdb:memType="252" xdb:system="false" xdb:mutable="false"
             xdb:JavaType="boolean" default="false" xdb:hidden="false"
             xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="744" name="HierSchmResource" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="false" xdb:JavaType="boolean" default="false"
             xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="753" name="SizeAccurate" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="false" xdb:JavaType="boolean" default="false"
             xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="756" name="IsVersionable" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="false" xdb:JavaType="boolean" default="false"
             xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="757" name="IsCheckedOut" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="false" xdb:JavaType="boolean" default="false"
             xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="758" name="IsVersion" type="boolean" xdb:memByteLength="1"
             xdb:memType="252" xdb:system="false" xdb:mutable="false"
             xdb:JavaType="boolean" default="false" xdb:hidden="true"
             xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="759" name="IsVCR" type="boolean" xdb:memByteLength="1"
             xdb:memType="252" xdb:system="false" xdb:mutable="false"
             xdb:JavaType="boolean" default="false" xdb:hidden="true"
             xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="760" name="IsVersionHistory" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="false" xdb:JavaType="boolean" default="false"
             xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="761" name="IsWorkspace" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="false" xdb:JavaType="boolean" default="false"
             xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="776" name="HasUnresolvedLinks" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="false" xdb:JavaType="boolean" default="false"
             xdb:hidden="false" xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="777" name="IsXMLIndexed" type="boolean"
             xdb:memByteLength="1" xdb:memType="252" xdb:system="false"
             xdb:mutable="true" xdb:JavaType="boolean" default="false" xdb:hidden="true"
             xdb:transient="generated" xdb:baseProp="false"/>
</complexType>
<element xdb:propNumber="734" name="Resource" type="xdb:ResourceType" xdb:memType="258"
         xdb:system="false" xdb:mutable="false" xdb:SQLName="RESOURCE"
         xdb:SQLType="XDB$RESOURCE_T" xdb:SQLSchema="XDB" xdb:JavaType="XMLType"
         xdb:global="true" nillable="false" abstract="false" xdb:SQLInline="false"
         xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
         xdb:defaultTable="XDB$RESOURCE" xdb:defaultTableSchema="XDB"
         xdb:JavaClassname="oracle.xdb.ResourceBean"
```

```
          xdb:beanClassname="oracle.xdb.ResourceBean" xdb:numCols="33" minOccurs="1"
          maxOccurs="1"/>
  <element xdb:propNumber="775" name="Locks" type="xdb:locksType" xdb:memType="258"
          xdb:system="false" xdb:mutable="true" xdb:JavaType="XMLType" xdb:global="false"
          xdb:hidden="false" nillable="false" abstract="false" xdb:SQLInline="true"
          xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
          xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
</schema>
```

XDBResConfig.xsd: XML Schema for Resource Configuration

This section presents the Oracle XML DB supplied XML schema used to configure repository resources. This is accessible in Oracle XML DB Repository at path `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResConfig.xsd`.

XDBResConfig.xsd

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        targetNamespace="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        xmlns:rescfg="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
        elementFormDefault="qualified" xdb:schemaOwner="XDB" version="1.0">
  <annotation>
    <documentation>
      This XML schema declares the schema of an XDB resource configuration,
      which includes default ACL, event listeners and user configuration.
      It lists all XDB repository events that will be supported.

      Future extension can be added to support user-defined events and
      XML events.
    </documentation>
  </annotation>
  <simpleType name="language">
    <restriction base="string">
      <enumeration value="Java"/>
      <enumeration value="C"/>
      <enumeration value="PL/SQL"/>
    </restriction>
  </simpleType>
  <complexType name="existsNode">
    <all>
      <element name="XPath" type="string" minOccurs="1" maxOccurs="1"/>
      <element name="namespace" type="string" minOccurs="0" maxOccurs="1"/>
    </all>
  </complexType>
  <!-- listener pre-condition element  -->
  <complexType name="condition">
    <all>
      <element name="existsNode" type="rescfg:existsNode" minOccurs="0" maxOccurs="1"/>
    </all>
  </complexType>
  <complexType name="events">
    <all>
      <element name="Render" type="string" minOccurs="0" maxOccurs="1"/>
      <element name="Pre-Create" type="string" minOccurs="0" maxOccurs="1"/>
      <element name="Post-Create" type="string" minOccurs="0" maxOccurs="1"/>
      <element name="Pre-Delete" type="string" minOccurs="0" maxOccurs="1"/>
      <element name="Post-Delete" type="string" minOccurs="0" maxOccurs="1"/>
      <element name="Pre-Update" type="string" minOccurs="0" maxOccurs="1"/>
```

```
    <element name="Post-Update" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Lock" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Lock" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Unlock" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Unlock" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-LinkIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-LinkIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-LinkTo" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-LinkTo" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-UnlinkIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-UnlinkIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-UnlinkFrom" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-UnlinkFrom" type="string" minOccurs="0"/ maxOccurs="1">
    <element name="Pre-CheckIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-CheckIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-CheckOut" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-CheckOut" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-UncheckOut" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-UncheckOut" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-VersionControl" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-VersionControl" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Open" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Open" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-InconsistentUpdate" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-InconsistentUpdate" type="string" minOccurs="0" maxOccurs="1"/>
  </all>
</complexType>
<!-- event listener element  -->
<complexType name="event-listener">
  <all>
    <element name="description" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="schema" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="source" type="string"  minOccurs="1" maxOccurs="1"/>
    <element name="language" type="rescfg:language" minOccurs="0" maxOccurs="1"/>
    <element name="pre-condition" type="rescfg:condition" minOccurs="0" maxOccurs="1"/>
    <element name="events" type="rescfg:events" minOccurs="0" maxOccurs="1"/>
  </all>
</complexType>
<complexType name="event-listeners">
  <sequence>
    <element name="listener" type="rescfg:event-listener" minOccurs="1" maxOccurs="unbounded"/>
  </sequence>
  <attribute name="default-schema" type="string" xdb:baseProp="true" use="optional"/>
  <attribute name="default-language" type="rescfg:language" xdb:baseProp="true" use="optional"/>
  <attribute name="set-invoker" type="boolean" xdb:baseProp="true" default="false"/>
</complexType>
<complexType name="defaultPath">
  <all>
    <element name="pre-condition" type="rescfg:condition" minOccurs="0" maxOccurs="1"/>
    <element name="path" type="string" minOccurs="0" maxOccurs="1" xdb:transient="generated"/>
    <element name="resolvedpath" type="string" minOccurs="1" maxOccurs="1"
             xdb:baseProp="true" xdb:hidden="true"/>
    <element name="oid" type="hexBinary"minOccurs="1" maxOccurs="1"
             xdb:baseProp="true" xdb:hidden="true"/>
  </all>
</complexType>
<complexType name="defaultACL">
  <sequence>
    <element name="ACL" type="rescfg:defaultPath" minOccurs="1" maxOccurs="unbounded"/>
  </sequence>
```

```
</complexType>
<complexType name="defaultConfig">
  <sequence>
    <element name="configuration" type="rescfg:defaultPath"
             minOccurs="1" maxOccurs="unbounded"/>
  </sequence>
</complexType>
<simpleType name="link-type">
  <restriction base="string">
    <enumeration value="None"/>
    <enumeration value="Hard"/>
    <enumeration value="Weak"/>
    <enumeration value="Symbolic"/>
  </restriction>
</simpleType>
<simpleType name="path-format">
  <restriction base="string">
    <enumeration value="OID"/>
    <enumeration value="Named"/>
  </restriction>
</simpleType>
<simpleType name="link-metadata">
  <restriction base="string">
    <enumeration value="None"/>
    <enumeration value="Attributes"/>
    <enumeration value="All"/>
  </restriction>
</simpleType>
<simpleType name="unresolved-link">
  <restriction base="string">
    <enumeration value="Error"/>
    <enumeration value="SymLink"/>
    <enumeration value="Skip"/>
  </restriction>
</simpleType>
<simpleType name="conflict-rule">
  <restriction base="string">
    <enumeration value="Error"/>
    <enumeration value="Overwrite"/>
    <enumeration value="Syspath"/>
  </restriction>
</simpleType>
<simpleType name="section-type">
  <restriction base="string">
    <enumeration value="None"/>
    <enumeration value="Fragment"/>
    <enumeration value="Document"/>
  </restriction>
</simpleType>
<!-- XLinkConfig complex type -->
<complexType name="xlink-config">
  <sequence>
    <element name="LinkType" type="rescfg:link-type"/>
    <element name="PathFormat" type="rescfg:path-format" minOccurs="0" default="OID"/>
    <element name="LinkMetadata" type="rescfg:link-metadata" minOccurs="0" default="None"/>
    <element name="pre-condition" type="rescfg:condition" minOccurs="0 "maxOccurs="1"/>
  </sequence>
  <attribute name="UnresolvedLink" type="rescfg:unresolved-link" default="Error"/>
</complexType>
<!-- XIncludeConfig element -->
```

```
  <complexType name="xinclude-config">
    <sequence>
      <element name="LinkType" type="rescfg:link-type"/>
      <element name="PathFormat" type="rescfg:path-format" minOccurs="0" default="OID"/>
      <element name="ConflictRule" type="rescfg:conflict-rule" minOccurs="0" default="Error"/>
    </sequence>
    <attribute name="UnresolvedLink" type="rescfg:unresolved-link" default="Error"/>
  </complexType>
  <!-- SectionConfig element -->
  <complexType name="section-config">
    <sequence>
      <element name="Section" maxOccurs="unbounded">
        <complexType>
          <sequence>
            <element name="sectionPath" type="string"/>
            <element name="documentPath" type="string" minOccurs="0"/>
            <element name="namespace" type="string" minOccurs="0"/>
          </sequence>
          <attribute name="type" type="rescfg:section-type" default="None"/>
        </complexType>
      </element>
    </sequence>
  </complexType>
  <!-- ContentFormat element -->
  <simpleType name="content-format">
    <restriction base="string">
      <enumeration value="text"/>
      <enumeration value="binary"/>
    </restriction>
  </simpleType>
  <!-- resource configuration element  -->
  <complexType name="ResConfig">
    <all>
      <element name="defaultChildConfig" type="rescfg:defaultConfig" minOccurs="0" maxOccurs="1"/>
      <element name="defaultChildACL" type="rescfg:defaultACL" minOccurs="0" maxOccurs="1"/>
      <element name="event-listeners" type="rescfg:event-listeners" minOccurs="0" maxOccurs="1"/>
      <element name="XLinkConfig" type="rescfg:xlink-config" minOccurs="0" maxOccurs="1"/>
      <element name="XIncludeConfig" type="rescfg:xinclude-config" minOccurs="0" maxOccurs="1"/>
      <element name="SectionConfig" type="rescfg:section-config" minOccurs="0" maxOccurs="1"/>
      <element name="ContentFormat" type="rescfg:content-format" minOccurs="0" maxOccurs="1"/>
      <!-- application data -->
      <element name="applicationData" minOccurs="0" maxOccurs="1">
        <complexType>
          <sequence>
            <any namespace="##other" maxOccurs="unbounded" processContents="lax"/>
          </sequence>
        </complexType>
      </element>
    </all>
    <attribute name="enable" type="boolean" xdb:baseProp="true" default="true"/>
    <attribute name="copy-on-inconsistent-update" type="boolean" use="optional"/>
  </complexType>
  <element name="ResConfig" type="rescfg:ResConfig" xdb:defaultTable="XDB$RESCONFIG"/>
</schema>
```

acl.xsd: XML Schema for ACLs

This section presents the Oracle Database supplied XML schema used to represent access control lists (ACLs).

acl.xsd

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        targetNamespace="http://xmlns.oracle.com/xdb/acl.xsd" version="1.0"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        xmlns:xdbacl="http://xmlns.oracle.com/xdb/acl.xsd"
        elementFormDefault="qualified">
  <annotation>
    <documentation>
       This XML schema describes the structure of XDB ACL documents.

       Note : The "systemPrivileges" element below lists all supported
         system privileges and their aggregations.
         See dav.xsd for description of DAV privileges
       Note : The elements and attributes marked "hidden" are for
         internal use only.
    </documentation>
    <appinfo>
      <xdb:systemPrivileges>
        <xdbacl:all>
          <xdbacl:read-properties/>
          <xdbacl:read-contents/>
          <xdbacl:read-acl/>
          <xdbacl:update/>
          <xdbacl:link/>
          <xdbacl:unlink/>
          <xdbacl:unlink-from/>
          <xdbacl:write-acl-ref/>
          <xdbacl:update-acl/>
          <xdbacl:link-to/>
          <xdbacl:resolve/>
          <xdbacl:write-config/>
        </xdbacl:all>
      </xdb:systemPrivileges>
    </appinfo>
  </annotation>
  <!-- privilegeNameType (this is an emptycontent type) -->
  <complexType name = "privilegeNameType"/>
  <!-- privilegeName element
       All system and user privileges are in the substitutionGroup
       of this element.
    -->
  <element name = "privilegeName" type="xdbacl:privilegeNameType"
           xdb:defaultTable=""/>
  <!-- all system privileges in the XDB ACL namespace -->
  <element name = "read-properties" type="xdbacl:privilegeNameType"
           substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
  <element name = "read-contents" type="xdbacl:privilegeNameType"
           substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
  <element name = "read-acl" type="xdbacl:privilegeNameType"
           substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
  <element name = "update" type="xdbacl:privilegeNameType"
           substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
  <element name = "link" type="xdbacl:privilegeNameType"
           substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
  <element name = "unlink" type="xdbacl:privilegeNameType"
           substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
  <element name = "unlink-from" type="xdbacl:privilegeNameType"
           substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
  <element name = "write-acl-ref" type="xdbacl:privilegeNameType"
           substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
```

```
<element name = "update-acl" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "link-to" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "resolve" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "all" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<!-- privilege element -->
<element name = "privilege" xdb:defaultTable="">
  <complexType>
    <sequence>
      <any maxOccurs="unbounded" processContents="lax"/>
    </sequence>
  </complexType>
</element>
<!-- ace element -->
<element name = "ace" xdb:defaultTable="">
  <complexType>
    <sequence>
      <element name = "grant" type = "boolean"/>
      <choice>
        <element name="invert" xdb:transient="generated">
          <complexType>
            <sequence>
              <element name="principal" type="string"
                       xdb:transient="generated" />
            </sequence>
          </complexType>
        </element>
        <element name="principal" type="string" xdb:transient="generated"/>
      </choice>
      <element ref="xdbacl:privilege" minOccurs="1"/>
      <!-- "any" contain all app info for an ACE e.g.reason for creation -->
      <any minOccurs="0" maxOccurs="unbounded" namespace="##other"
           processContents="lax"/>
      <!-- HIDDEN ELEMENTS -->
      <choice minOccurs="0">
        <element name = "principalID" type = "hexBinary"
                 xdb:baseProp="true" xdb:hidden="true"/>
        <element name = "principalString" type = "string"
                 xdb:baseProp="true" xdb:hidden="true"/>
      </choice>
      <element name = "flags" type = "unsignedInt" minOccurs="0"
               xdb:baseProp="true" xdb:hidden="true"/>
    </sequence>
    <attribute name = "collection" type = "boolean"
               xdb:transient="generated" use="optional"/>
    <attribute name = "principalFormat"
               xdb:transient="generated" use="optional">
      <simpleType>
        <restriction base="string">
          <enumeration value="ShortName"/>
          <enumeration value="DistinguishedName"/>
          <enumeration value="GUID"/>
          <enumeration value="XSName"/>
          <enumeration value="ApplicationName"/>
        </restriction>
      </simpleType>
    </attribute>
```

```
    <attribute name = "start_date" type = "dateTime" use = "optional"/>
    <attribute name = "end_date" type = "dateTime" use = "optional"/>
  </complexType>
</element>
<!-- acl element -->
<complexType name="inheritanceType">
  <attribute name="type" type="string" use="required"/>
  <attribute name="href" type="string" use="required"/>
</complexType>
<complexType name="aclType">
  <sequence>
    <element name = "schemaURL" type = "string" minOccurs="0"
             xdb:transient="generated"/>
    <element name = "elementName" type = "string" minOccurs="0"
             xdb:transient="generated"/>
    <element name = "security-class" type = "QName" minOccurs="0"/>
    <choice minOccurs="0">
      <element name="extends-from" type="xdbacl:inheritanceType"/>
      <element name="constrained-with" type="xdbacl:inheritanceType"/>
    </choice>
    <element ref = "xdbacl:ace" minOccurs="0" maxOccurs = "unbounded"/>
    <!-- this "any" contains all application specific info for an ACL,
         e.g., reason for creation  -->
    <any minOccurs="0" maxOccurs="unbounded" namespace="##other"
         processContents="lax"/>
    <!-- HIDDEN ELEMENTS -->
    <element name = "schemaOID" type = "hexBinary" minOccurs="0"
             xdb:baseProp="true" xdb:hidden="true"/>
    <element name = "elementNum" type = "unsignedInt" minOccurs="0"
             xdb:baseProp="true" xdb:hidden="true"/>
  </sequence>
  <attribute name = "shared" type = "boolean" default="true"/>
  <attribute name = "description" type = "string"/>
</complexType>
<complexType name="rule-based-acl">
  <complexContent>
    <extension base="xdbacl:aclType">
      <sequence>
        <element name = "param" minOccurs="0" maxOccurs="unbounded">
          <complexType>
            <simpleContent>
              <extension base="string">
                <attribute name = "name" type = "string" use = "required"/>
              </extension>
            </simpleContent>
          </complexType>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<element name = "acl" type="xdbacl:aclType" xdb:defaultTable = "XDB$ACL"/>
<element name = "write-config" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
</schema>
```

xdbconfig.xsd: XML Schema for Configuring Oracle XML DB

File `xdbconfig.xsd` contains the Oracle XML DB supplied XML schema used to configure Oracle XML DB.

> **Note:** The value of attribute `value` of element `pattern` has been split here for documentation purposes. In reality, the value is not split (no newline characters), but is one long string.

xdbconfig.xsd

```
<schema targetNamespace="http://xmlns.oracle.com/xdb/xdbconfig.xsd"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdbc="http://xmlns.oracle.com/xdb/xdbconfig.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        version="1.0" elementFormDefault="qualified">
  <element name="xdbconfig" xdb:defaultTable="XDB$CONFIG">
    <complexType>
      <sequence>

        <!-- predefined XDB properties - these should NOT be changed -->
        <element name="sysconfig">
          <complexType>
            <sequence>

              <!-- generic XDB properties -->
              <element name="acl-max-age" type="unsignedInt" default="15"/>
              <element name="acl-cache-size" type="unsignedInt" default="32"/>
              <element name="invalid-pathname-chars" type="string" default=""/>
              <element name="case-sensitive" type="boolean" default="true"/>
              <element name="call-timeout"   type="unsignedInt" default="300"/>
              <element name="max-link-queue" type="unsignedInt" default="65536"/>
              <element name="max-session-use" type="unsignedInt" default="100"/>
              <element name="persistent-sessions" type="boolean" default="false"/>
              <element name="default-lock-timeout" type="unsignedInt"
                       default="3600"/>
              <element name="xdbcore-logfile-path" type="string"
                       default="/sys/log/xdblog.xml"/>
              <element name="xdbcore-log-level" type="unsignedInt"
                       default="0"/>
              <element name="resource-view-cache-size" type="unsignedInt"
                       default="1048576"/>
              <element name="case-sensitive-index-clause" type="string"
                       minOccurs="0"/>

              <!-- protocol specific properties -->
              <element name="protocolconfig">
                <complexType>
                  <sequence>

                    <!-- these apply to all protocols -->
                    <element name="common">
                      <complexType>
                        <sequence>
                          <element name="extension-mappings">
                            <complexType>
                              <sequence>
                                <element name="mime-mappings"
                                         type="xdbc:mime-mapping-type"/>
```

```
            <element name="lang-mappings"
                     type="xdbc:lang-mapping-type"/>
            <element name="charset-mappings"
                     type="xdbc:charset-mapping-type"/>
            <element name="encoding-mappings"
                     type="xdbc:encoding-mapping-type"/>
            <element name="xml-extensions"
                     type="xdbc:xml-extension-type"
                     minOccurs="0"/>
          </sequence>
        </complexType>
      </element>
      <element name="session-pool-size" type="unsignedInt"
               default="50"/>
      <element name="session-timeout" type="unsignedInt"
               default="6000"/>
    </sequence>
  </complexType>
</element>

<!-- FTP specific -->
<element name="ftpconfig">
  <complexType>
    <sequence>
      <element name="ftp-port" type="unsignedShort"
               default="2100"/>
      <element name="ftp-listener" type="string"/>
      <element name="ftp-protocol" type="string"/>
      <element name="logfile-path" type="string"
               default="/sys/log/ftplog.xml"/>
      <element name="log-level" type="unsignedInt"
               default="0"/>
      <element name="session-timeout"  type="unsignedInt"
               default="6000"/>
      <element name="buffer-size" default="8192">
        <simpleType>
          <restriction base="unsignedInt">
            <minInclusive value="1024"/>       <!-- 1KB -->
            <maxInclusive value="1048496"/>    <!-- 1MB -->
          </restriction>
        </simpleType>
      </element>
      <element name="ftp-welcome-message" type="string"
               minOccurs="0" maxOccurs="1"/>
      <element name="host-name" type="string"
               minOccurs="0" maxOccurs="1"/>
    </sequence>
  </complexType>
</element>

<!-- HTTP specific -->
<element name="httpconfig">
  <complexType>
    <sequence>
      <element name="http-port" type="unsignedShort"
               default="8080"/>
      <element name="http-listener" type="string"/>
      <element name="http-protocol" type="string"/>
      <element name="max-http-headers" type="unsignedInt"
               default="64"/>
```

```
<element name="max-header-size" type="unsignedInt"
         default="4096"/>
<element name="max-request-body" type="unsignedInt"
         default="2000000000" minOccurs="1"/>
<element name="session-timeout"  type="unsignedInt"
         default="6000"/>
<element name="server-name" type="string"/>
<element name="logfile-path" type="string"
         default="/sys/log/httplog.xml"/>
<element name="log-level" type="unsignedInt"
         default="0"/>
<element name="servlet-realm" type="string"
         minOccurs="0"/>
<element name="webappconfig">
  <complexType>
    <sequence>
      <element name="welcome-file-list"
               type="xdbc:welcome-file-type"/>
      <element name="error-pages"
               type="xdbc:error-page-type"/>
      <element name="servletconfig"
               type="xdbc:servlet-config-type"/>
    </sequence>
  </complexType>
</element>
<element name="default-url-charset" type="string"
         minOccurs="0"/>
<element name="http2-port" type="unsignedShort"
         minOccurs="0"/>
<element name="http2-protocol" type="string"
         default="tcp" minOccurs="0"/>
<element name="plsql" minOccurs="0">
  <complexType>
    <sequence>
      <element name="log-level"
               type="unsignedInt" minOccurs="0"/>
      <element name="max-parameters"
               type="unsignedInt" minOccurs="0"/>
    </sequence>
  </complexType>
</element>
<element name="allow-repository-anonymous-access"
         minOccurs="0" default="false" type="boolean"/>
<element name="authentication" minOccurs="0"
         maxOccurs="1">
  <complexType>
    <sequence>
      <element name="allow-mechanism" minOccurs="1"
               maxOccurs="unbounded">
        <simpleType>
          <restriction base="string">
            <enumeration value="digest"/>
            <enumeration value="basic" />
            <enumeration value="custom"/>
          </restriction>
        </simpleType>
      </element>
      <element name="digest-auth" minOccurs="0"
               maxOccurs="1">
        <complexType>
```

```
                    <sequence>
                      <element name="nonce-timeout"
                               type="unsignedInt"
                               minOccurs="1" maxOccurs="1"
                               default="300"/>
                    </sequence>
                  </complexType>
                </element>
              </sequence>
            </complexType>
          </element>
          <element name="http-host" type="string" minOccurs="0"/>
          <element name="http2-host" type="string" minOccurs="0"/>
          <element name="custom-authentication"
                   type="xdbc:custom-authentication-type"
                   minOccurs="0"/>
          <element name="realm" type="string" minOccurs="0"/>
          <element name="respond-with-server-info" type="boolean"
                   default="true" minOccurs="0"/>
          <element name="expire" type="xdbc:expire-type"
                   minOccurs="0"/>
          <element name="white-list" minOccurs="0">
            <complexType>
              <sequence>
                <element name="white-list-pattern" minOccurs="0"
                         maxOccurs="unbounded">
                  <simpleType>
                    <restriction base="string">
                      <pattern value="(/[^\*/]+)*(/\*)?"/>
                    </restriction>
                  </simpleType>
                </element>
              </sequence>
            </complexType>
          </element>
        </sequence>
      </complexType>
    </element>
    <element name="nfsconfig" minOccurs="0">
      <complexType>
        <sequence>
          <element name="nfs-port" type="unsignedShort"
                   default="2049"/>
          <element name="nfs-listener" type="string"/>
          <element name="nfs-protocol" type="string"/>
          <element name="logfile-path" type="string"
                   default="/sys/log/nfslog.xml"/>
          <element name="log-level" type="unsignedInt"
                   default="0"/>
          <element name="nfs-exports"
                   type="xdbc:nfs-exports-type"/>
        </sequence>
      </complexType>
    </element>
  </sequence>
 </complexType>
</element>
<element name="schemaLocation-mappings"
         type="xdbc:schemaLocation-mapping-type" minOccurs="0"/>
<element name="xdbcore-xobmem-bound" type="unsignedInt"
```

```
                default="1024" minOccurs="0"/>
            <element name="xdbcore-loadableunit-size" type="unsignedInt"
                default="16" minOccurs="0"/>
            <element name="folder-hard-links" type="boolean" default="false"
                minOccurs="0"/>
            <element name="non-folder-hard-links" type="boolean" default="true"
                minOccurs="0"/>
            <element name="copy-on-inconsistent-update" type="boolean"
                default="false" minOccurs="0"/>
            <element name="rollback-on-sync-error" type="boolean"
                default="false" minOccurs="0"/>
            <element name="acl-evaluation-method" default="deny-trumps-grant"
                minOccurs="0">
              <simpleType>
                <restriction base="string">
                  <enumeration value="deny-trumps-grant"/>
                  <enumeration value="ace-order"/>
                </restriction>
              </simpleType>
            </element>
            <element name="default-workspace" type="string" minOccurs="0"/>
            <element name="num_job_queue_processes" type="unsignedInt"
                minOccurs="0"/>
            <element name="allow-authentication-trust" type="boolean"
                default="false" minOccurs="0"/>
            <element name="custom-authentication-trust"
                type="xdbc:custom-authentication-trust-type"
                minOccurs="0"/>
            <element name="default-type-mappings" minOccurs="0">
              <simpleType>
                <restriction base="string">
                  <enumeration value="pre-11.2"/>
                  <enumeration value="post-11.2"/>
                </restriction>
              </simpleType>
            </element>
            <element name="localApplicationGroupStore" type="boolean"
                default="true" minOccurs="0"/>
          </sequence>
        </complexType>
      </element>

      <!-- users can add any properties they want here -->
      <element name="userconfig" minOccurs="0">
        <complexType>
          <sequence>
            <any maxOccurs="unbounded" namespace="##other"/>
          </sequence>
        </complexType>
      </element>
    </sequence>
  </complexType>
</element>
<complexType name="welcome-file-type">
  <sequence>
    <element name="welcome-file" minOccurs="0" maxOccurs="unbounded">
      <simpleType>
        <restriction base="string">
          <pattern value="[^/]*"/>
        </restriction>
```

```
      </simpleType>
    </element>
  </sequence>
</complexType>

<!-- customized error pages -->
<complexType name="error-page-type">
  <sequence>
    <element name="error-page" minOccurs="0" maxOccurs="unbounded">
      <complexType>
        <sequence>
          <choice>
            <element name="error-code">
              <simpleType>
                <restriction base="positiveInteger">
                  <minInclusive value="100"/>
                  <maxInclusive value="999"/>
                </restriction>
              </simpleType>
            </element>

            <!-- Fully qualified classname of a Java exception type -->
            <element name="exception-type" type="string"/>
            <element name="OracleError">
              <complexType>
                <sequence>
                   <element name="facility" type="string" default="ORA"/>
                   <element name="errnum" type="unsignedInt"/>
                </sequence>
              </complexType>
            </element>
          </choice>
          <element name="location" type="anyURI"/>
        </sequence>
      </complexType>
    </element>
  </sequence>
</complexType>

<!-- parameter for a servlet: name, value pair and a description  -->
<complexType name="param">
  <sequence>
    <element name="param-name" type="string"/>
    <element name="param-value" type="string"/>
    <element name="description" type="string"/>
  </sequence>
</complexType>
<complexType name="servlet-config-type">
  <sequence>
    <element name="servlet-mappings">
      <complexType>
        <sequence>
          <element name="servlet-mapping" minOccurs="0"
                   maxOccurs="unbounded">
            <complexType>
              <sequence>
                <element name="servlet-pattern" type="string"/>
                <element name="servlet-name" type="string"/>
              </sequence>
            </complexType>
```

```
      </element>
    </sequence>
  </complexType>
</element>
<element name="servlet-list">
  <complexType>
    <sequence>
      <element name="servlet" minOccurs="0" maxOccurs="unbounded">
        <complexType>
          <sequence>
            <element name="servlet-name" type="string"/>
            <element name="servlet-language">
              <simpleType>
                <restriction base="string">
                  <enumeration value="C"/>
                  <enumeration value="Java"/>
                  <enumeration value="PL/SQL"/>
                </restriction>
              </simpleType>
            </element>
            <element name="icon" type="string" minOccurs="0"/>
            <element name="display-name" type="string"/>
            <element name="description" type="string" minOccurs="0"/>
            <choice>
              <element name="servlet-class" type="string" minOccurs="0"/>
              <element name="jsp-file" type="string" minOccurs="0"/>
              <element name="plsql" type="xdbc:plsql-servlet-config"
                       minOccurs="0"/>
            </choice>
            <element name="servlet-schema" type="string" minOccurs="0"/>
            <element name="init-param" minOccurs="0"
                     maxOccurs="unbounded" type="xdbc:param"/>
            <element name="load-on-startup" type="string" minOccurs="0"/>
            <element name="security-role-ref" minOccurs="0"
                     maxOccurs="unbounded">
              <complexType>
                <sequence>
                  <element name="description" type="string" minOccurs="0"/>
                  <element name="role-name" type="string"/>
                  <element name="role-link" type="string"/>
                </sequence>
              </complexType>
            </element>
            <!-- session-state-cache-param captures all the parameters
                 of the session state cache. expiration-timeout is
                 specified in centi-seconds. -->
            <element name="session-state-cache-param" minOccurs="0">
              <complexType>
                <sequence>
                  <element name="cache-size" type="unsignedInt"/>
                  <element name="expiration-timeout" type="unsignedInt"/>
                </sequence>
              </complexType>
            </element>
          </sequence>
        </complexType>
      </element>
    </sequence>
  </complexType>
</element>
```

```
  </sequence>
</complexType>
<complexType name="lang-mapping-type">
  <sequence>
    <element name="lang-mapping" minOccurs="0" maxOccurs="unbounded">
      <complexType>
        <sequence>
          <element name="extension" type="xdbc:exttype"/>
          <element name="lang" type="string"/>
        </sequence>
      </complexType>
    </element>
  </sequence>
</complexType>
<complexType name="charset-mapping-type">
  <sequence>
    <element name="charset-mapping" minOccurs="0" maxOccurs="unbounded">
      <complexType>
        <sequence>
          <element name="extension" type="xdbc:exttype"/>
          <element name="charset" type="string"/>
        </sequence>
      </complexType>
    </element>
  </sequence>
</complexType>
<complexType name="encoding-mapping-type">
  <sequence>
    <element name="encoding-mapping" minOccurs="0" maxOccurs="unbounded">
      <complexType>
        <sequence>
          <element name="extension" type="xdbc:exttype"/>
          <element name="encoding" type="string"/>
        </sequence>
      </complexType>
    </element>
  </sequence>
</complexType>
<complexType name="mime-mapping-type">
  <sequence>
    <element name="mime-mapping" minOccurs="0" maxOccurs="unbounded">
      <complexType>
        <sequence>
          <element name="extension" type="xdbc:exttype"/>
          <element name="mime-type" type="string"/>
        </sequence>
      </complexType>
    </element>
  </sequence>
</complexType>
<complexType name="xml-extension-type">
  <sequence>
    <element name="extension" type="xdbc:exttype"
             minOccurs="0" maxOccurs="unbounded">
    </element>
  </sequence>
</complexType>
<complexType name="schemaLocation-mapping-type">
  <sequence>
    <element name="schemaLocation-mapping"
```

```
            minOccurs="0" maxOccurs="unbounded">
      <complexType>
        <sequence>
          <element name="namespace" type="string"/>
          <element name="element" type="string"/>
          <element name="schemaURL" type="string"/>
        </sequence>
      </complexType>
    </element>
  </sequence>
</complexType>
<complexType name="plsql-servlet-config">
  <sequence>
    <element name="database-username" type="string" minOccurs="0"/>
    <element name="authentication-mode" minOccurs="0">
      <simpleType>
        <restriction base="string">
          <enumeration value="Basic"/>
          <enumeration value="SingleSignOn"/>
          <enumeration value="GlobalOwa"/>
          <enumeration value="CustomOwa"/>
          <enumeration value="PerPackageOwa"/>
        </restriction>
      </simpleType>
    </element>
    <element name="session-cookie-name" type="string" minOccurs="0"/>
    <element name="session-state-management" minOccurs="0">
      <simpleType>
        <restriction base="string">
          <enumeration value="StatelessWithResetPackageState"/>
          <enumeration value="StatelessWithFastResetPackageState"/>
          <enumeration value="StatelessWithPreservePackageState"/>
        </restriction>
      </simpleType>
    </element>
    <element name="max-requests-per-session" type="unsignedInt" minOccurs="0"/>
    <element name="default-page" type="string" minOccurs="0"/>
    <element name="document-table-name" type="string" minOccurs="0"/>
    <element name="document-path" type="string" minOccurs="0"/>
    <element name="document-procedure" type="string" minOccurs="0"/>
    <element name="upload-as-long-raw" type="string" minOccurs="0"
             maxOccurs="unbounded"/>
    <element name="path-alias" type="string" minOccurs="0"/>
    <element name="path-alias-procedure" type="string" minOccurs="0"/>
    <element name="exclusion-list" type="string" minOccurs="0"
             maxOccurs="unbounded"/>
    <element name="cgi-environment-list" type="string" minOccurs="0"
             maxOccurs="unbounded"/>
    <element name="compatibility-mode" type="unsignedInt" minOccurs="0"/>
    <element name="nls-language" type="string" minOccurs="0"/>
    <element name="fetch-buffer-size" type="unsignedInt" minOccurs="0"/>
    <element name="error-style" minOccurs="0">
      <simpleType>
        <restriction base="string">
          <enumeration value="ApacheStyle"/>
          <enumeration value="ModplsqlStyle"/>
          <enumeration value="DebugStyle"/>
        </restriction>
      </simpleType>
    </element>
```

```
      <element name="transfer-mode" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="Char"/>
            <enumeration value="Raw"/>
          </restriction>
        </simpleType>
      </element>
      <element name="before-procedure" type="string" minOccurs="0"/>
      <element name="after-procedure" type="string" minOccurs="0"/>
      <element name="bind-bucket-lengths" type="unsignedInt" minOccurs="0"
               maxOccurs="unbounded"/>
      <element name="bind-bucket-widths" type="unsignedInt" minOccurs="0"
               maxOccurs="unbounded"/>
      <element name="always-describe-procedure" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="On"/>
            <enumeration value="Off"/>
          </restriction>
        </simpleType>
      </element>
      <element name="info-logging" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="InfoDebug"/>
          </restriction>
        </simpleType>
      </element>
      <element name="owa-debug-enable" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="On"/>
            <enumeration value="Off"/>
          </restriction>
        </simpleType>
      </element>
      <element name="request-validation-function" type="string" minOccurs="0"/>
      <element name="input-filter-enable" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="On"/>
            <enumeration value="Off"/>
            <enumeration value="SecurityOn"/>
            <enumeration value="SecurityOff"/>
          </restriction>
        </simpleType>
      </element>
      <element name="database-edition" type="string" minOccurs="0"/>
    </sequence>
  </complexType>
  <simpleType name="exttype">
    <restriction base="string">
      <pattern value="[^\*\./]*"/>
    </restriction>
  </simpleType>
  <simpleType name="ipaddress">
    <restriction base="string">
      <maxLength value="40" />
    </restriction>
```

```
</simpleType>
<complexType name="nfs-exports-type">
  <sequence>
    <element name="nfs-export" minOccurs="1" maxOccurs="unbounded">
      <complexType>
        <sequence>
          <element name="nfs-clientgroup">
            <complexType>
              <sequence>
                <element name="nfs-client" minOccurs="1" maxOccurs="unbounded">
                  <complexType>
                    <sequence>
                      <choice>
                        <element name="nfs-client-subnet"
                                 type="xdbc:ipaddress"/>
                        <element name="nfs-client-dnsname" type="string"/>
                        <element name="nfs-client-address"
                                 type="xdbc:ipaddress"/>
                      </choice>
                      <element name="nfs-client-netmask"
                               type="xdbc:ipaddress"/>
                    </sequence>
                  </complexType>
                </element>
              </sequence>
            </complexType>
          </element>
          <element name="nfs-export-paths">
            <complexType>
              <sequence>
                <element name="nfs-export-path" minOccurs="1"
                         maxOccurs="unbounded">
                  <complexType>
                    <sequence>
                      <element name="path" type="string"/>
                      <element name="mode">
                        <simpleType>
                          <restriction base="string">
                            <enumeration value="read-write"/>
                            <enumeration value="read-only"/>
                          </restriction>
                        </simpleType>
                      </element>
                    </sequence>
                  </complexType>
                </element>
              </sequence>
            </complexType>
          </element>
        </sequence>
      </complexType>
    </element>
  </sequence>
</complexType>
<complexType name="custom-authentication-type">
  <sequence>
    <element name="custom-authentication-mappings">
      <complexType>
        <sequence>
          <element name="custom-authentication-mapping" minOccurs="0"
```

```
                maxOccurs="unbounded">
            <complexType>
              <sequence>
                <element name="authentication-pattern" type="string"/>
                <element name="authentication-name" type="string"/>
                <element name="authentication-trust-name" type="string"
                         minOccurs="0"/>
                <element name="user-prefix" type="string" minOccurs="0"/>
                <element name="on-deny" minOccurs="0">
                  <simpleType><restriction base="string">
                    <enumeration value="next-custom"/>
                    <enumeration value="basic"/>
                  </restriction></simpleType>
                </element>
              </sequence>
            </complexType>
          </element>
        </sequence>
      </complexType>
    </element>
    <element name="custom-authentication-list">
      <complexType>
        <sequence>
          <element name="authentication" minOccurs="0" maxOccurs="unbounded">
            <complexType>
              <sequence>
                <element name="authentication-name" type="string"/>
                <element name="authentication-description" type="string"
                         minOccurs="0"/>
                <element name="authentication-implement-schema" type="string"/>
                <element name="authentication-implement-method" type="string"/>
                <element name="authentication-implement-language">
                  <simpleType>
                    <restriction base="string">
                      <enumeration value="PL/SQL"/>
                    </restriction>
                  </simpleType>
                </element>
              </sequence>
            </complexType>
          </element>
        </sequence>
      </complexType>
    </element>
    <element name="custom-authentication-trust"
             type="xdbc:custom-authentication-trust-type" minOccurs="0"/>
  </sequence>
</complexType>
<complexType name="custom-authentication-trust-type">
  <sequence>
    <element name="trust-scheme"  minOccurs="0" maxOccurs="unbounded">
      <complexType>
        <sequence>
          <element name="trust-scheme-name" type="string"/>
          <element name="requireParsingSchema" type="boolean" default="true"
                   minOccurs="0"/>
          <element name="allowRegistration" type="boolean" default="true"
                   minOccurs="0"/>
          <element name="trust-scheme-description" type="string" minOccurs="0"/>
          <element name="trusted-session-user" type="string"  minOccurs="1"
```

```
                    maxOccurs="unbounded"/>
            <element name="trusted-parsing-schema" type="string" minOccurs="0"
                    maxOccurs="unbounded"/>
          </sequence>
        </complexType>
      </element>
    </sequence>
  </complexType>
  <complexType name="expire-type">
    <sequence>
      <element name="expire-mapping" minOccurs="0" maxOccurs="unbounded">
        <complexType>
          <sequence>
            <element name="expire-pattern" type="string"/>
            <element name="expire-default">
              <simpleType>
                <restriction base="string">
                  <pattern value=
"(now|modification)(\s(plus))?(\s(([1]\s(year))|
([0-9]*\s(years))))?(\s(([1]\s(month))|([0-9]*\s(months))))?(\s(([1]\s(week))|
([0-9]*\s(weeks))))?(\s(([1]\s(day))|([0-9]*\s(days))))?(\s(([1]\s(hour))|
([0-9]*\s(hours))))?(\s(([1]\s(minute))|
([0-9]*\s(minutes))))?(\s(([1]\s(second))|([0-9]*\s(seconds))))?"/>[1]
                </restriction>
              </simpleType>
            </element>
          </sequence>
        </complexType>
      </element>
    </sequence>
  </complexType>
</schema>
```

xdiff.xsd: XML Schema for Comparing Schemas for In-Place Evolution

`xdiff.xsd`, is the Oracle XML DB-supplied XML schema to which the document specified as the `diffXML` parameter to procedure `DBMS_XMLSCHEMA.inPlaceEvolve` must conform.

xdiff.xsd

```
<schema targetNamespace="http://xmlns.oracle.com/xdb/xdiff.xsd"
    xmlns="http://www.w3.org/2001/XMLSchema"
    xmlns:xd="http://xmlns.oracle.com/xdb/xdiff.xsd"
    version="1.0" elementFormDefault="qualified"
    attributeFormDefault="qualified">
    <annotation>
        <documentation xml:lang="en">
         Defines the structure of XML documents that capture the difference
         between two XML documents. Changes that are not supported by Oracle
         XmlDiff may not be expressible in this schema.

        'oracle-xmldiff' PI:

        We use 'oracle-xmldiff' PI to describe certain aspects of the diff.
        This should be the first element of top level xdiff element.
```

[1] The value of attribute `value` has been split here for documentation purposes. In reality, the value is one long string, with no line breaks.

```
    operations-in-docorder:
    Can be either 'true' or 'false'.
    If true, the operations in the diff document refer to the
    elements of the input doc in the same order as document order. Output of
    global algorithm meets this requirement while local does not.

    output-model: output models for representing the diff. Can be either
    'Snapshot' or 'Current'.

    Snapshot model:
    Each operation uses Xpaths as if no operations
    have been applied to the input document. (like UNIX diff)
    Default and works for both Xmldiff and XmlPatch.
    For XmlPatch to handle this model, "operations-in-docorder" must be
    true and the Xpaths must be simple. (see XmlDif C API documentation).

    Current model :
    Each operation uses Xpaths as if all operations till the previous one
    have been applied to the input document. Not implemented for Xmldiff.
    Works with XmlPatch.

    <!-- Example:
        <?oracle-xmldiff operations-in-docorder="true" output-model=
        "snapshot" diff-algorithm="global"?>
    -->
    </documentation>
</annotation>
<!-- Enumerate the supported node types -->
<simpleType name="xdiff-nodetype">
    <restriction base="string">
        <enumeration value="element"/>
        <enumeration value="attribute"/>
        <enumeration value="text"/>
        <enumeration value="cdata"/>
        <enumeration value="entity-reference"/>
        <enumeration value="entity"/>
        <enumeration value="processing-instruction"/>
        <enumeration value="notation"/>
        <enumeration value="comment"/>
     </restriction>
</simpleType>

<element name="xdiff">
    <complexType>
        <choice minOccurs="0" maxOccurs="unbounded">
            <element name="append-node">
                <complexType>
                    <sequence>
                        <element name="content" type="anyType"/>
                    </sequence>
                    <attribute name="node-type" type="xd:xdiff-nodetype"/>
                    <attribute name="xpath" type="string"/>
                    <attribute name="parent-xpath" type="string"/>
                    <attribute name="attr-local" type="string"/>
                    <attribute name="attr-uri" type="string"/>
                </complexType>
            </element>

            <element name="insert-node-before">
```

```
                    <complexType>
                        <sequence>
                            <element name="content" type="anyType"/>
                        </sequence>
                        <attribute name="xpath" type="string"/>
                        <attribute name="node-type" type="xd:xdiff-nodetype"/>

                    </complexType>
                </element>

                <element name="delete-node">
                    <complexType>
                        <attribute name="node-type" type="xd:xdiff-nodetype"/>
                        <attribute name="xpath" type="string"/>
                        <attribute name="parent-xpath" type="string"/>
                        <attribute name="attr-local" type="string"/>
                        <attribute name="attr-uri" type="string"/>
                    </complexType>
                </element>
                 <element name="update-node">
                    <complexType>
                        <sequence>
                            <element name="content" type="anyType"/>
                        </sequence>
                        <attribute name="node-type" type="xd:xdiff-nodetype"/>
                        <attribute name="parent-xpath" type="string"/>
                        <attribute name="xpath" type="string"/>
                        <attribute name="attr-local" type="string"/>
                        <attribute name="attr-uri" type="string"/>
                    </complexType>
                </element>
                <element name="rename-node">
                    <complexType>
                        <sequence>
                            <element name="content" type="anyType"/>
                        </sequence>
                        <attribute name="xpath" type="string"/>
                        <attribute name="node-type" type="xd:xdiff-nodetype"/>
                    </complexType>
                </element>
            </choice>
             <attribute name="xdiff-version" type="string"/>
            </complexType>
        </element>
    </schema>
```

Purchase-Order XML Schemas

This section contains the complete listings of purchase-order XML schemas used in various examples throughout the book.

Example A–1 shows an unannotated purchase-order XML schema.

Example A–1 Unannotated Purchase-Order XML Schema

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" version="1.0">
  <xs:element name="PurchaseOrder" type="PurchaseOrderType"/>
  <xs:complexType name="PurchaseOrderType">
    <xs:sequence>
      <xs:element name="Reference" type="ReferenceType"/>
```

```
    <xs:element name="Actions" type="ActionsType"/>
    <xs:element name="Reject" type="RejectionType" minOccurs="0"/>
    <xs:element name="Requestor" type="RequestorType"/>
    <xs:element name="User" type="UserType"/>
    <xs:element name="CostCenter" type="CostCenterType"/>
    <xs:element name="ShippingInstructions" type="ShippingInstructionsType"/>
    <xs:element name="SpecialInstructions" type="SpecialInstructionsType"/>
    <xs:element name="LineItems" type="LineItemsType"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="LineItemsType">
  <xs:sequence>
    <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="LineItemType">
  <xs:sequence>
    <xs:element name="Description" type="DescriptionType"/>
    <xs:element name="Part" type="PartType"/>
  </xs:sequence>
  <xs:attribute name="ItemNumber" type="xs:integer"/>
</xs:complexType>
<xs:complexType name="PartType">
  <xs:attribute name="Id">
    <xs:simpleType>
      <xs:restriction base="xs:string">
        <xs:minLength value="10"/>
        <xs:maxLength value="14"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="Quantity" type="moneyType"/>
  <xs:attribute name="UnitPrice" type="quantityType"/>
</xs:complexType>
<xs:simpleType name="ReferenceType">
  <xs:restriction base="xs:string">
    <xs:minLength value="18"/>
    <xs:maxLength value="30"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="ActionsType">
  <xs:sequence>
    <xs:element name="Action" maxOccurs="4">
      <xs:complexType>
        <xs:sequence>
          <xs:element name="User" type="UserType"/>
          <xs:element name="Date" type="DateType" minOccurs="0"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="RejectionType">
  <xs:all>
    <xs:element name="User" type="UserType" minOccurs="0"/>
    <xs:element name="Date" type="DateType" minOccurs="0"/>
    <xs:element name="Comments" type="CommentsType" minOccurs="0"/>
  </xs:all>
</xs:complexType>
<xs:complexType name="ShippingInstructionsType">
```

```
  <xs:sequence>
    <xs:element name="name" type="NameType" minOccurs="0"/>
    <xs:element name="address" type="AddressType" minOccurs="0"/>
    <xs:element name="telephone" type="TelephoneType" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="moneyType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="2"/>
    <xs:totalDigits value="12"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="quantityType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="4"/>
    <xs:totalDigits value="8"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="UserType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="10"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="RequestorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="128"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="CostCenterType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="4"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="VendorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="20"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="PurchaseOrderNumberType">
  <xs:restriction base="xs:integer"/>
</xs:simpleType>
<xs:simpleType name="SpecialInstructionsType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="2048"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="NameType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="20"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="AddressType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
```

```
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="TelephoneType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="24"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DateType">
    <xs:restriction base="xs:date"/>
  </xs:simpleType>
  <xs:simpleType name="CommentsType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="2048"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DescriptionType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

Example A–3 represents a modified version of Example A–2. The modification is used in Chapter 20 to illustrate XML schema evolution. Example A–2 is the complete listing of the annotated XML schema used in examples of Chapter 17, "XML Schema Storage and Query: Basic".

Example A–2 Annotated Purchase-Order XML Schema

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0"
           xdb:storeVarrayAsTable="true">
  <xs:element name="PurchaseOrder" type="PurchaseOrderType" xdb:defaultTable="PURCHASEORDER"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Reference" type="ReferenceType" minOccurs="1" xdb:SQLName="REFERENCE"/>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" minOccurs="1" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                  xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                  xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
      <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"
                  xdb:SQLName="LINEITEM" xdb:SQLCollType="LINEITEM_V"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Description" type="DescriptionType"
                  xdb:SQLName="DESCRIPTION"/>
      <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
```

```
  </xs:sequence>
  <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                xdb:SQLType="NUMBER"/>
</xs:complexType>
<xs:complexType name="PartType" xdb:SQLType="PART_T">
  <xs:attribute name="Id" xdb:SQLName="PART_NUMBER" xdb:SQLType="VARCHAR2">
    <xs:simpleType>
      <xs:restriction base="xs:string">
        <xs:minLength value="10"/>
        <xs:maxLength value="14"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="Quantity" type="moneyType" xdb:SQLName="QUANTITY"/>
  <xs:attribute name="UnitPrice" type="quantityType" xdb:SQLName="UNITPRICE"/>
</xs:complexType>
<xs:simpleType name="ReferenceType">
  <xs:restriction base="xs:string">
    <xs:minLength value="18"/>
    <xs:maxLength value="30"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="ActionsType" xdb:SQLType="ACTIONS_T">
  <xs:sequence>
    <xs:element name="Action" maxOccurs="4" xdb:SQLName="ACTION" xdb:SQLCollType="ACTION_V">
      <xs:complexType xdb:SQLType="actioN_t">
        <xs:sequence>
          <xs:element name="User" type="UserType" xdb:SQLName="ACTIONED_BY"/>
          <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_ACTIONED"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
  <xs:all>
    <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
    <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
    <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
  </xs:all>
</xs:complexType>
<xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
  <xs:sequence>
    <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
    <xs:element name="address" type="AddressType" minOccurs="0" xdb:SQLName="SHIP_TO_ADDRESS"/>
    <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="moneyType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="2"/>
    <xs:totalDigits value="12"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="quantityType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="4"/>
    <xs:totalDigits value="8"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="UserType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="10"/>
  </xs:restriction>
</xs:simpleType>
```

```
  <xs:simpleType name="RequestorType">
    <xs:restriction base="xs:string">
      <xs:minLength value="0"/>
      <xs:maxLength value="128"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CostCenterType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="4"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="VendorType">
    <xs:restriction base="xs:string">
      <xs:minLength value="0"/>
      <xs:maxLength value="20"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="PurchaseOrderNumberType">
    <xs:restriction base="xs:integer"/>
  </xs:simpleType>
  <xs:simpleType name="SpecialInstructionsType">
    <xs:restriction base="xs:string">
      <xs:minLength value="0"/>
      <xs:maxLength value="2048"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="NameType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="20"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="AddressType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="TelephoneType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="24"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DateType">
    <xs:restriction base="xs:date"/>
  </xs:simpleType>
  <xs:simpleType name="CommentsType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="2048"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DescriptionType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

Example A–3 is the complete listing of the revised annotated XML schema presented in Example 20–1 on page 20-2. Text that is in **bold face** is additional or significantly different from that in the schema of Example A–2.

Example A–3 Revised Annotated Purchase-Order XML Schema

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0">
  <xs:element
    name="PurchaseOrder" type="PurchaseOrderType"
    xdb:defaultTable="PURCHASEORDER"
    xdb:columnProps=
      "CONSTRAINT purchaseorder_pkey PRIMARY KEY (XMLDATA.reference),
       CONSTRAINT valid_email_address FOREIGN KEY (XMLDATA.userid)
         REFERENCES hr.employees (EMAIL)"
    xdb:tableProps=
      "VARRAY XMLDATA.ACTIONS.ACTION STORE AS TABLE ACTION_TABLE
        ((CONSTRAINT action_pkey PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
       VARRAY XMLDATA.LINEITEMS.LINEITEM STORE AS TABLE LINEITEM_TABLE
        ((constraint LINEITEM_PKEY primary key (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
       lob (XMLDATA.NOTES) STORE AS (ENABLE STORAGE IN ROW STORAGE(INITIAL 4K NEXT 32K))"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="BillingAddress" type="AddressType" minOccurs="0"
                  xdb:SQLName="BILLING_ADDRESS"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                  xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                  xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
      <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
      <xs:element name="Notes" type="NotesType" minOccurs="0" xdb:SQLType="CLOB"
                  xdb:SQLName="NOTES"/>
    </xs:sequence>
    <xs:attribute name="Reference" type="ReferenceType" use="required" xdb:SQLName="REFERENCE"/>
    <xs:attribute name="DateCreated" type="xs:dateTime" use="required"
                  xdb:SQLType="TIMESTAMP WITH TIME ZONE"/>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded" xdb:SQLName="LINEITEM"
                  xdb:SQLCollType="LINEITEM_V"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
      <xs:element name="Quantity" type="quantityType"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                  xdb:SQLType="NUMBER"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T">
    <xs:simpleContent>
      <xs:extension base="UPCCodeType">
        <xs:attribute name="Description" type="DescriptionType" use="required"
                      xdb:SQLName="DESCRIPTION"/>
        <xs:attribute name="UnitCost" type="moneyType" use="required"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
  <xs:simpleType name="ReferenceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="18"/>
      <xs:maxLength value="30"/>
    </xs:restriction>
```

```
</xs:simpleType>
<xs:complexType name="ActionsType" xdb:SQLType="ACTIONS_T">
  <xs:sequence>
    <xs:element name="Action" maxOccurs="4" xdb:SQLName="ACTION" xdb:SQLCollType="ACTION_V">
      <xs:complexType xdb:SQLType="ACTION_T">
        <xs:sequence>
          <xs:element name="User" type="UserType" xdb:SQLName="ACTIONED_BY"/>
          <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_ACTIONED"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
  <xs:all>
    <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
    <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
    <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
  </xs:all>
</xs:complexType>
<xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
  <xs:sequence>
    <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
    <xs:choice>
      <xs:element name="address" type="AddressType" minOccurs="0"/>
      <xs:element name="fullAddress" type="FullAddressType" minOccurs="0"
                  xdb:SQLName="SHIP_TO_ADDRESS"/>
    </xs:choice>
    <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="moneyType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="2"/>
    <xs:totalDigits value="12"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="quantityType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="4"/>
    <xs:totalDigits value="8"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="UserType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="10"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="RequestorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="128"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="CostCenterType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="4"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="VendorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="20"/>
  </xs:restriction>
```

```
</xs:simpleType>
<xs:simpleType name="PurchaseOrderNumberType">
  <xs:restriction base="xs:integer"/>
</xs:simpleType>
<xs:simpleType name="SpecialInstructionsType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="2048"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="NameType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="20"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="FullAddressType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="256"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="TelephoneType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="24"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="DateType">
        <xs:restriction base="xs:date"/>
</xs:simpleType>
<xs:simpleType name="CommentsType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="2048"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="DescriptionType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="256"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="AddressType" xdb:SQLType="ADDRESS_T">
  <xs:sequence>
    <xs:element name="StreetLine1" type="StreetType"/>
    <xs:element name="StreetLine2" type="StreetType" minOccurs="0"/>
    <xs:element name="City" type="CityType"/>
    <xs:choice>
      <xs:sequence>
        <xs:element name="State" type="StateType"/>
        <xs:element name="ZipCode" type="ZipCodeType"/>
      </xs:sequence>
      <xs:sequence>
        <xs:element name="Province" type="ProvinceType"/>
        <xs:element name="PostCode" type="PostCodeType"/>
      </xs:sequence>
      <xs:sequence>
        <xs:element name="County" type="CountyType"/>
        <xs:element name="Postcode" type="PostCodeType"/>
      </xs:sequence>
    </xs:choice>
    <xs:element name="Country" type="CountryType"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="StreetType">
```

```
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="128"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CityType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="64"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="StateType">
    <xs:restriction base="xs:string">
      <xs:minLength value="2"/>
      <xs:maxLength value="2"/>
      <xs:enumeration value="AK"/>
      <xs:enumeration value="AL"/>
      <xs:enumeration value="AR"/>
      <xs:enumeration value="AS"/>
      <xs:enumeration value="AZ"/>
      <xs:enumeration value="CA"/>
      <xs:enumeration value="CO"/>
      <xs:enumeration value="CT"/>
      <xs:enumeration value="DC"/>
      <xs:enumeration value="DE"/>
      <xs:enumeration value="FL"/>
      <xs:enumeration value="FM"/>
      <xs:enumeration value="GA"/>
      <xs:enumeration value="GU"/>
      <xs:enumeration value="HI"/>
      <xs:enumeration value="IA"/>
      <xs:enumeration value="ID"/>
      <xs:enumeration value="IL"/>
      <xs:enumeration value="IN"/>
      <xs:enumeration value="KS"/>
      <xs:enumeration value="KY"/>
      <xs:enumeration value="LA"/>
      <xs:enumeration value="MA"/>
      <xs:enumeration value="MD"/>
      <xs:enumeration value="ME"/>
      <xs:enumeration value="MH"/>
      <xs:enumeration value="MI"/>
      <xs:enumeration value="MN"/>
      <xs:enumeration value="MO"/>
      <xs:enumeration value="MP"/>
      <xs:enumeration value="MQ"/>
      <xs:enumeration value="MS"/>
      <xs:enumeration value="MT"/>
      <xs:enumeration value="NC"/>
      <xs:enumeration value="ND"/>
      <xs:enumeration value="NE"/>
      <xs:enumeration value="NH"/>
      <xs:enumeration value="NJ"/>
      <xs:enumeration value="NM"/>
      <xs:enumeration value="NV"/>
      <xs:enumeration value="NY"/>
      <xs:enumeration value="OH"/>
      <xs:enumeration value="OK"/>
      <xs:enumeration value="OR"/>
      <xs:enumeration value="PA"/>
      <xs:enumeration value="PR"/>
      <xs:enumeration value="PW"/>
      <xs:enumeration value="RI"/>
      <xs:enumeration value="SC"/>
      <xs:enumeration value="SD"/>
      <xs:enumeration value="TN"/>
```

```
      <xs:enumeration value="TX"/>
      <xs:enumeration value="UM"/>
      <xs:enumeration value="UT"/>
      <xs:enumeration value="VA"/>
      <xs:enumeration value="VI"/>
      <xs:enumeration value="VT"/>
      <xs:enumeration value="WA"/>
      <xs:enumeration value="WI"/>
      <xs:enumeration value="WV"/>
      <xs:enumeration value="WY"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ZipCodeType">
    <xs:restriction base="xs:string">
      <xs:pattern value="\d{5}"/>
      <xs:pattern value="\d{5}-\d{4}"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CountryType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="64"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CountyType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="32"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="PostCodeType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="12"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ProvinceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="2"/>
      <xs:maxLength value="2"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="NotesType">
    <xs:restriction base="xs:string">
      <xs:maxLength value="32767"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="UPCCodeType">
    <xs:restriction base="xs:string">
      <xs:minLength value="11"/>
      <xs:maxLength value="14"/>
      <xs:pattern value="\d{11}"/>
      <xs:pattern value="\d{12}"/>
      <xs:pattern value="\d{13}"/>
      <xs:pattern value="\d{14}"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

XSLT Stylesheet Example, PurchaseOrder.xsl

Example A–4 shows XSLT stylesheet `PurchaseOrder.xsl`. The same stylesheet is used in other examples in this book.

Example A–4 PurchaseOrder.xsl XSLT Stylesheet

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="1.0"
                xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
                xmlns:xdb="http://xmlns.oracle.com/xdb"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <xsl:template match="/">
    <html>
      <head/>
      <body bgcolor="#003333" text="#FFFFCC" link="#FFCC00"
            vlink="#66CC99" alink="#669999">
        <FONT FACE="Arial, Helvetica, sans-serif">
          <xsl:for-each select="PurchaseOrder"/>
          <xsl:for-each select="PurchaseOrder">
            <center>
              <span style="font-family:Arial; font-weight:bold">
                <FONT COLOR="#FF0000">
                  <B>Purchase Order </B>
                </FONT>
              </span>
            </center>
            <br/>
            <center>
              <xsl:for-each select="Reference">
                <span style="font-family:Arial; font-weight:bold">
                  <xsl:apply-templates/>
                </span>
              </xsl:for-each>
            </center>
          </xsl:for-each>
          <P>
            <xsl:for-each select="PurchaseOrder">
              <br/>
            </xsl:for-each>
            <P/>
            <P>
              <xsl:for-each select="PurchaseOrder">
                <br/>
              </xsl:for-each>
            </P>
          </P>
          <xsl:for-each select="PurchaseOrder"/>
          <xsl:for-each select="PurchaseOrder">
            <table border="0" width="100%" BGCOLOR="#000000">
              <tbody>
                <tr>
                  <td WIDTH="296">
                    <P>
                      <B>
                        <FONT SIZE="+1" COLOR="#FF0000"
                         FACE="Arial, Helvetica, sans-serif">Internal
                        </FONT>
                      </B>
                    </P>
                    <table border="0" width="98%" BGCOLOR="#000099">
                      <tbody>
                        <tr>
                          <td WIDTH="49%">
                            <B>
                              <FONT COLOR="#FFFF00">Actions</FONT>
```

```
    </B>
  </td>
  <td WIDTH="51%">
    <xsl:for-each select="Actions">
      <xsl:for-each select="Action">
        <table border="1" WIDTH="143">
          <xsl:if test="position()=1">
            <thead>
              <tr>
                <td HEIGHT="21">
                  <FONT
                   COLOR="#FFFF00">User</FONT>
                </td>
                <td HEIGHT="21">
                  <FONT
                   COLOR="#FFFF00">Date</FONT>
                </td>
              </tr>
            </thead>
          </xsl:if>
          <tbody>
            <tr>
              <td>
                <xsl:for-each select="User">
                  <xsl:apply-templates/>
                </xsl:for-each>
              </td>
              <td>
                <xsl:for-each select="Date">
                  <xsl:apply-templates/>
                </xsl:for-each>
              </td>
            </tr>
          </tbody>
        </table>
      </xsl:for-each>
    </xsl:for-each>
  </td>
</tr>
<tr>
  <td WIDTH="49%">
    <B>
      <FONT COLOR="#FFFF00">Requestor</FONT>
    </B>
  </td>
  <td WIDTH="51%">
    <xsl:for-each select="Requestor">
      <xsl:apply-templates/>
    </xsl:for-each>
  </td>
</tr>
<tr>
  <td WIDTH="49%">
    <B>
      <FONT COLOR="#FFFF00">User</FONT>
    </B>
  </td>
  <td WIDTH="51%">
    <xsl:for-each select="User">
      <xsl:apply-templates/>
```

```
            </xsl:for-each>
          </td>
        </tr>
        <tr>
          <td WIDTH="49%">
            <B>
              <FONT COLOR="#FFFF00">Cost Center</FONT>
            </B>
          </td>
          <td WIDTH="51%">
            <xsl:for-each select="CostCenter">
              <xsl:apply-templates/>
            </xsl:for-each>
          </td>
        </tr>
      </tbody>
    </table>
  </td>
  <td width="93"/>
  <td valign="top" WIDTH="340">
    <B>
      <FONT COLOR="#FF0000">
        <FONT SIZE="+1">Ship To</FONT>
      </FONT>
    </B>
    <xsl:for-each select="ShippingInstructions">
      <xsl:if test="position()=1"/>
    </xsl:for-each>
    <xsl:for-each select="ShippingInstructions">
      <xsl:if test="position()=1">
        <table border="0" BGCOLOR="#999900">
          <tbody>
            <tr>
              <td WIDTH="126" HEIGHT="24">
                <B>Name</B>
              </td>
              <xsl:for-each
                   select="../ShippingInstructions">
                <td WIDTH="218" HEIGHT="24">
                  <xsl:for-each select="name">
                    <xsl:apply-templates/>
                  </xsl:for-each>
                </td>
              </xsl:for-each>
            </tr>
            <tr>
              <td WIDTH="126" HEIGHT="34">
                <B>Address</B>
              </td>
              <xsl:for-each
                   select="../ShippingInstructions">
                <td WIDTH="218" HEIGHT="34">
                  <xsl:for-each select="address">
                    <span style="white-space:pre">
                      <xsl:apply-templates/>
                    </span>
                  </xsl:for-each>
                </td>
              </xsl:for-each>
            </tr>
```

```
                    <tr>
                      <td WIDTH="126" HEIGHT="32">
                        <B>Telephone</B>
                      </td>
                      <xsl:for-each
                           select="../ShippingInstructions">
                        <td WIDTH="218" HEIGHT="32">
                          <xsl:for-each select="telephone">
                            <xsl:apply-templates/>
                          </xsl:for-each>
                        </td>
                      </xsl:for-each>
                    </tr>
                  </tbody>
                </table>
              </xsl:if>
            </xsl:for-each>
          </td>
        </tr>
      </tbody>
    </table>
    <br/>
    <B>
      <FONT COLOR="#FF0000" SIZE="+1">Items:</FONT>
    </B>
    <br/>
    <br/>
    <table border="0">
      <xsl:for-each select="LineItems">
        <xsl:for-each select="LineItem">
          <xsl:if test="position()=1">
            <thead>
              <tr bgcolor="#C0C0C0">
                <td>
                  <FONT COLOR="#FF0000">
                    <B>ItemNumber</B>
                  </FONT>
                </td>
                <td>
                  <FONT COLOR="#FF0000">
                    <B>Description</B>
                  </FONT>
                </td>
                <td>
                  <FONT COLOR="#FF0000">
                    <B>PartId</B>
                  </FONT>
                </td>
                <td>
                  <FONT COLOR="#FF0000">
                    <B>Quantity</B>
                  </FONT>
                </td>
                <td>
                  <FONT COLOR="#FF0000">
                    <B>Unit Price</B>
                  </FONT>
                </td>
                <td>
                  <FONT COLOR="#FF0000">
```

```
            <B>Total Price</B>
          </FONT>
        </td>
      </tr>
    </thead>
  </xsl:if>
  <tbody>
    <tr bgcolor="#DADADA">
      <td>
        <FONT COLOR="#000000">
          <xsl:for-each select="@ItemNumber">
            <xsl:value-of select="."/>
          </xsl:for-each>
        </FONT>
      </td>
      <td>
        <FONT COLOR="#000000">
          <xsl:for-each select="Description">
            <xsl:apply-templates/>
          </xsl:for-each>
        </FONT>
      </td>
      <td>
        <FONT COLOR="#000000">
          <xsl:for-each select="Part">
            <xsl:for-each select="@Id">
              <xsl:value-of select="."/>
            </xsl:for-each>
          </xsl:for-each>
        </FONT>
      </td>
      <td>
        <FONT COLOR="#000000">
          <xsl:for-each select="Part">
            <xsl:for-each select="@Quantity">
              <xsl:value-of select="."/>
            </xsl:for-each>
          </xsl:for-each>
        </FONT>
      </td>
      <td>
        <FONT COLOR="#000000">
          <xsl:for-each select="Part">
            <xsl:for-each select="@UnitPrice">
              <xsl:value-of select="."/>
            </xsl:for-each>
          </xsl:for-each>
        </FONT>
      </td>
      <td>
        <FONT FACE="Arial, Helvetica, sans-serif"
              COLOR="#000000">
          <xsl:for-each select="Part">
            <xsl:value-of select="@Quantity*@UnitPrice"/>
          </xsl:for-each>
        </FONT>
      </td>
    </tr>
  </tbody>
</xsl:for-each>
```

```
                    </xsl:for-each>
                  </table>
                </xsl:for-each>
              </FONT>
            </body>
          </html>
        </xsl:template>
      </xsl:stylesheet>
```

Loading XML Data Using C (OCI)

Example A–5 is a C program that inserts XML data into an `XMLType` table. It is partly listed in "Loading XML Content Using C" on page 3-10.

Example A–5 Inserting XML Data into an XMLType Table Using C

```
#include "stdio.h"
#include <xml.h>
#include <stdlib.h>
#include <string.h>
#include <ocixmldb.h>
OCIEnv *envhp;
OCIError *errhp;
OCISvcCtx *svchp;
OCIStmt *stmthp;
OCIServer *srvhp;
OCIDuration dur;
OCISession *sesshp;
oratext *username = "QUINE";
oratext *password = "*************";      /* Replace with real password */
oratext *filename = "AMCEWEN-20021009123336171PDT.xml";
oratext *schemaloc = "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd";

/* Execute a SQL statement that binds XML data */
sword exec_bind_xml(OCISvcCtx *svchp, OCIError *errhp, OCIStmt *stmthp,
                    void *xml,        OCIType *xmltdo, OraText *sqlstmt)
{
  OCIBind *bndhp1 = (OCIBind *) 0;
  sword  status = 0;
  OCIInd ind = OCI_IND_NOTNULL;
  OCIInd *indp = &ind;
  if(status = OCIStmtPrepare(stmthp, errhp, (OraText *)sqlstmt,
                             (ub4)strlen((const char *)sqlstmt),
                             (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  if(status = OCIBindByPos(stmthp, &bndhp1, errhp, (ub4) 1, (dvoid *) 0,
                           (sb4) 0, SQLT_NTY, (dvoid *) 0, (ub2 *)0,
                           (ub2 *)0, (ub4) 0, (ub4 *) 0, (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  if(status = OCIBindObject(bndhp1, errhp, (CONST OCIType *) xmltdo,
                            (dvoid **) &xml, (ub4 *) 0,
                            (dvoid **) &indp, (ub4 *) 0))
    return OCI_ERROR;
  if(status = OCIStmtExecute(svchp, stmthp, errhp, (ub4) 1, (ub4) 0,
                             (CONST OCISnapshot*) 0, (OCISnapshot*) 0,
                             (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  return OCI_SUCCESS;
}

/* Initialize OCI handles, and connect  */
sword init_oci_connect()
```

```
{
  sword status;
  if (OCIEnvCreate((OCIEnv **) &(envhp), (ub4) OCI_OBJECT,
                   (dvoid *) 0, (dvoid * (*)(dvoid *,size_t)) 0,
                   (dvoid * (*)(dvoid *, dvoid *, size_t)) 0,
                   (void (*)(dvoid *, dvoid *)) 0, (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIEnvCreate()\n");
      return OCI_ERROR;
    }
  /* Allocate error handle */
  if (OCIHandleAlloc((dvoid *) envhp, (dvoid **) &(errhp),
                     (ub4) OCI_HTYPE_ERROR, (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on errhp\n");
      return OCI_ERROR;
    }
  /* Allocate server handle */
  if (status = OCIHandleAlloc((dvoid *) envhp, (dvoid **) &srvhp,
                              (ub4) OCI_HTYPE_SERVER, (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on srvhp\n");
      return OCI_ERROR;
    }
  /* Allocate service context handle */
  if (status = OCIHandleAlloc((dvoid *) envhp,
                              (dvoid **) &(svchp), (ub4) OCI_HTYPE_SVCCTX,
                              (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on svchp\n");
      return OCI_ERROR;
    }
  /* Allocate session handle */
  if (status = OCIHandleAlloc((dvoid *) envhp, (dvoid **) &sesshp ,
                              (ub4) OCI_HTYPE_SESSION, (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on sesshp\n");
      return OCI_ERROR;
    }
  /* Allocate statement handle */
  if (OCIHandleAlloc((dvoid *)envhp, (dvoid **) &stmthp,
                     (ub4)OCI_HTYPE_STMT, (CONST size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on stmthp\n");
      return status;
    }
  if (status = OCIServerAttach((OCIServer *) srvhp, (OCIError *) errhp,
                               (CONST oratext *)"", 0, (ub4) OCI_DEFAULT))
    {
      printf("FAILED: OCIServerAttach() on srvhp\n");
      return OCI_ERROR;
    }
  /* Set server attribute to service context */
  if (status = OCIAttrSet((dvoid *) svchp, (ub4) OCI_HTYPE_SVCCTX,
                          (dvoid *) srvhp, (ub4) 0, (ub4) OCI_ATTR_SERVER,
                          (OCIError *) errhp))
    {
      printf("FAILED: OCIAttrSet() on svchp\n");
      return OCI_ERROR;
    }
  /* Set user attribute to session */
  if (status = OCIAttrSet((dvoid *)sesshp, (ub4) OCI_HTYPE_SESSION,
                          (dvoid *)username,
                          (ub4) strlen((const char *)username),
                          (ub4) OCI_ATTR_USERNAME, (OCIError *) errhp))
    {
```

```
      printf("FAILED: OCIAttrSet() on authp for user\n");
      return OCI_ERROR;
    }
  /* Set password attribute to session */
  if (status = OCIAttrSet((dvoid *) sesshp, (ub4) OCI_HTYPE_SESSION,
                          (dvoid *)password,
                          (ub4) strlen((const char *)password),
                          (ub4) OCI_ATTR_PASSWORD, (OCIError *) errhp))
    {
      printf("FAILED: OCIAttrSet() on authp for password\n");
      return OCI_ERROR;
    }
  /* Begin a session  */
  if (status = OCISessionBegin((OCISvcCtx *) svchp,
                               (OCIError *) errhp,
                               (OCISession *) sesshp, (ub4) OCI_CRED_RDBMS,
                               (ub4) OCI_STMT_CACHE))
    {
      printf("FAILED: OCISessionBegin(). Make sure database is up and the username/password is valid. \n");
      return OCI_ERROR;
    }
  /* Set session attribute to service context */
  if (status = OCIAttrSet((dvoid *) svchp, (ub4) OCI_HTYPE_SVCCTX,
                          (dvoid *)sesshp, (ub4) 0, (ub4) OCI_ATTR_SESSION,
                          (OCIError *) errhp))
    {
      printf("FAILED: OCIAttrSet() on svchp\n");
      return OCI_ERROR;
    }
}

/* Free OCI handles, and disconnect                        */
void free_oci()
{
  sword  status = 0;

  /* End the session */
  if (status = OCISessionEnd((OCISvcCtx *)svchp, (OCIError *)errhp,
                             (OCISession *)sesshp, (ub4) OCI_DEFAULT))
    {
      if (envhp)
        OCIHandleFree((dvoid *)envhp, OCI_HTYPE_ENV);
      return;
    }
  /* Detach from the server */
  if (status = OCIServerDetach((OCIServer *)srvhp, (OCIError *)errhp,
                               (ub4)OCI_DEFAULT))
    {
      if (envhp)
        OCIHandleFree((dvoid *)envhp, OCI_HTYPE_ENV);
      return;
    }
  /* Free the handles */
  if (stmthp) OCIHandleFree((dvoid *)stmthp, (ub4) OCI_HTYPE_STMT);
  if (sesshp) OCIHandleFree((dvoid *)sesshp, (ub4) OCI_HTYPE_SESSION);
  if (svchp) OCIHandleFree((dvoid *)svchp, (ub4) OCI_HTYPE_SVCCTX);
  if (srvhp) OCIHandleFree((dvoid *)srvhp, (ub4) OCI_HTYPE_SERVER);
  if (errhp) OCIHandleFree((dvoid *)errhp, (ub4) OCI_HTYPE_ERROR);
  if (envhp) OCIHandleFree((dvoid *)envhp, (ub4) OCI_HTYPE_ENV);
  return;
}

void main()
{
  OCIType *xmltdo;
  xmldocnode  *doc;
```

```
  ocixmldbparam params[1];
  xmlerr       err;
  xmlctx  *xctx;
  oratext *ins_stmt;
  sword    status;
  xmlnode *root;
  oratext buf[10000];

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_connect();

  /* Get an XML context */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &dur;
  xctx = OCIXmlDbInitXmlCtx(envhp, svchp, errhp, params, 1);
  if (!(doc = XmlLoadDom(xctx, &err, "file", filename,
                         "schema_location", schemaloc, NULL)))
    {
      printf("Parse failed.\n");
      return;
    }
  else
    printf("Parse succeeded.\n");
  root = XmlDomGetDocElem(xctx, doc);
  printf("The xml document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "buffer", buf, "buffer_length", 10000, NULL);
  printf("%s\n", buf);

  /* Insert the document into my_table */
  ins_stmt = (oratext *)"insert into purchaseorder values (:1)";
  status = OCITypeByName(envhp, errhp, svchp, (const text *) "SYS",
                         (ub4) strlen((const char *)"SYS"), (const text *) "XMLTYPE",
                         (ub4) strlen((const char *)"XMLTYPE"), (CONST text *) 0,
                         (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                         (OCIType **) &xmltdo);
  if (status == OCI_SUCCESS)
    {
      status = exec_bind_xml(svchp, errhp, stmthp, (void *)doc,
                             xmltdo, ins_stmt);
    }
  if (status == OCI_SUCCESS)
    printf ("Insert successful\n");
  else
    printf ("Insert failed\n");

  /* Free XML instances */
  if (doc) XmlFreeDocument((xmlctx *)xctx, (xmldocnode *)doc);

  /* Free XML CTX */
  OCIXmlDbFreeXmlCtx(xctx);
  free_oci();
}
```

Initializing and Terminating an XML Context (OCI)

Example A–6 shows how to use OCI functions `OCIXmlDbInitXmlCtx()` and `OCIXmlDbFreeXmlCtx()` to initialize and terminate the XML context. It constructs an XML document using the C DOM API and saves it to the database.

Example A–6 is partially listed in Chapter 14, "The C API for XML", "Initializing and Terminating an XML Context" on page 14-3. It assumes that the following SQL code has first been executed to create table `my_table` in database schema `CAPIUSER`:

```
CONNECT CAPIUSER
Enter password: <password>
```

```
Connected.

CREATE TABLE my_table OF XMLType;
```

Example A–6 Using OCIXmlDbInitXmlCtx() and OCIXmlDbFreeXmlCtx()

```
#ifndef S_ORACLE
#endif
#ifndef ORATYPES_ORACLE
#include <oratypes.h>
#endif
#ifndef XML_ORACLE
#include <xml.h>
#endif
#ifndef OCIXML_ORACLE
#include <ocixml.h>
#endif
#ifndef OCI_ORACLE
#include <oci.h>
#endif
#include <string.h>

typedef struct test_ctx {
        OCIEnv *envhp;
        OCIError *errhp;
        OCISvcCtx *svchp;
        OCIStmt *stmthp;
        OCIServer *srvhp;
        OCIDuration dur;
        OCISession *sesshp;
        oratext *username;
        oratext *password;
} test_ctx;

/* Helper function 1: execute a sql statement which binds xml data */
static sword exec_bind_xml(OCISvcCtx *svchp,
                           OCIError *errhp,
                           OCIStmt *stmthp,
                           void *xml,
                           OCIType *xmltdo,
                           OraText *sqlstmt);

/* Helper function 2: Initialize OCI handles and connect */
static sword init_oci_handles(test_ctx *ctx);

/* Helper function 3: Free OCI handles and disconnect */
static sword free_oci_handles(test_ctx *ctx);

void main()
{
  test_ctx temp_ctx;
  test_ctx *ctx = &temp_ctx;
  OCIType *xmltdo = (OCIType *) 0;
  xmldocnode *doc = (xmldocnode *)0;
  ocixmldbparam params[1];
  xmlnode *quux, *foo, *foo_data, *top;
  xmlerr err;
  sword status = 0;
  xmlctx *xctx;
```

```
oratext ins_stmt[] = "insert into my_table values (:1)";
oratext tlpxml_test_sch[] = "<TOP/>";
ctx->username = (oratext *)"CAPIUSER";
ctx->password = (oratext *)"************";   /* Replace with real password */

/* Initialize envhp, svchp, errhp, dur, stmthp */
init_oci_handles(ctx);

/* Get an xml context */
params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
params[0].value_ocixmldbparam = &ctx->dur;
xctx = OCIXmlDbInitXmlCtx(ctx->envhp, ctx->svchp, ctx->errhp, params, 1);

/* Start processing - first, check that this DOM supports XML 1.0 */
printf("\n\nSupports XML 1.0? : %s\n",
       XmlHasFeature(xctx, (oratext *) "xml", (oratext *) "1.0") ?
       "YES" : "NO");

/* Parse a document */
if (!(doc = XmlLoadDom(xctx, &err, "buffer", tlpxml_test_sch,
                       "buffer_length", sizeof(tlpxml_test_sch)-1,
                       "validate", TRUE, NULL)))
{
  printf("Parse failed, code %d\n", err);
}
else
{
  /* Get the document element */
  top = (xmlnode *)XmlDomGetDocElem(xctx, doc);

  /* Print out the top element */
  printf("\n\nOriginal top element is :\n");
  XmlSaveDom(xctx, &err, top, "stdio", stdout, NULL);

  /* Print out the document-note that the changes are reflected here */
  printf("\n\nOriginal document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "stdio", stdout, NULL);

  /* Create some elements and add them to the document */
  quux = (xmlnode *) XmlDomCreateElem(xctx ,doc, (oratext *) "QUUX");
  foo = (xmlnode *) XmlDomCreateElem(xctx, doc, (oratext *) "FOO");
  foo_data = (xmlnode *) XmlDomCreateText(xctx, doc, (oratext *) "data");
  foo_data = XmlDomAppendChild(xctx, (xmlnode *) foo, (xmlnode *) foo_data);
  foo = XmlDomAppendChild(xctx, quux, foo);
  quux = XmlDomAppendChild(xctx, top, quux);

  /* Print out the top element */
  printf("\n\nNow the top element is :\n");
  XmlSaveDom(xctx, &err, top, "stdio", stdout, NULL);

  /* Print out the document. Note that the changes are reflected here */
  printf("\n\nNow the document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "stdio", stdout, NULL);

  /* Insert the document into my_table */
  status = OCITypeByName(ctx->envhp, ctx->errhp, ctx->svchp,
                         (const text *) "SYS", (ub4) strlen((char *)"SYS"),
                         (const text *) "XMLTYPE",
                         (ub4) strlen((char *)"XMLTYPE"), (CONST text *) 0,
```

```
                          (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                          (OCIType **) &xmltdo);
    if (status == OCI_SUCCESS)
    {
      exec_bind_xml(ctx->svchp, ctx->errhp, ctx->stmthp, (void *)doc, xmltdo,
                    ins_stmt);
    }
  }
  /* Free xml ctx */
  OCIXmlDbFreeXmlCtx(xctx);

  /* Free envhp, svchp, errhp, stmthp */
  free_oci_handles(ctx);
}

/* Helper function 1: execute a SQL statement that binds xml data */
static sword exec_bind_xml(OCISvcCtx *svchp,
                          OCIError *errhp,
                          OCIStmt *stmthp,
                          void *xml,
                          OCIType *xmltdo,
                          OraText *sqlstmt)
{
  OCIBind *bndhp1 = (OCIBind *) 0;
  sword status = 0;
  OCIInd ind = OCI_IND_NOTNULL;
  OCIInd *indp = &ind;
  if(status = OCIStmtPrepare(stmthp, errhp, (OraText *)sqlstmt,
                           (ub4)strlen((char *)sqlstmt),
                           (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT)) {
    printf("Failed OCIStmtPrepare\n");
    return OCI_ERROR;
  }
  if(status = OCIBindByPos(stmthp, &bndhp1, errhp, (ub4) 1, (dvoid *) 0,
                          (sb4) 0, SQLT_NTY, (dvoid *) 0, (ub2 *)0,
                          (ub2 *)0, (ub4) 0, (ub4 *) 0, (ub4) OCI_DEFAULT)) {
    printf("Failed OCIBindByPos\n");
    return OCI_ERROR;
  }
  if(status = OCIBindObject(bndhp1, errhp, (CONST OCIType *) xmltdo, (dvoid **)
                           &xml,
                           (ub4 *) 0, (dvoid **) &indp, (ub4 *) 0)) {
    printf("Failed OCIBindObject\n");
    return OCI_ERROR;
  }
  if(status = OCIStmtExecute(svchp, stmthp, errhp, (ub4) 1, (ub4) 0,
                           (CONST OCISnapshot*) 0, (OCISnapshot*) 0,
                           (ub4) OCI_DEFAULT)) {
    printf("Failed OCIStmtExecute\n");
    return OCI_ERROR;
  }
  return OCI_SUCCESS;
}

/* Helper function 2: Initialize OCI handles and connect */
static sword init_oci_handles(test_ctx *ctx)
{
  sword status;
  ctx->dur = OCI_DURATION_SESSION;
  if (OCIEnvCreate((OCIEnv **) &(ctx->envhp), (ub4) OCI_OBJECT,
```

```
                (dvoid *) 0, (dvoid * (*)(dvoid *,size_t)) 0,
                (dvoid * (*)(dvoid *, dvoid *, size_t)) 0,
                (void (*)(dvoid *, dvoid *)) 0, (size_t) 0, (dvoid **) 0))
{
  printf("FAILED: OCIEnvCreate()\n");
  return OCI_ERROR;
}
/* Allocate error handle */
if (OCIHandleAlloc((dvoid *) ctx->envhp, (dvoid **) &(ctx->errhp),
                   (ub4) OCI_HTYPE_ERROR, (size_t) 0, (dvoid **) 0))
{
  printf("FAILED: OCIHandleAlloc() on errhp\n");
  return OCI_ERROR;
}
/* Allocate server handle */
if (status = OCIHandleAlloc((dvoid *) ctx->envhp, (dvoid **) &ctx->srvhp,
                         (ub4) OCI_HTYPE_SERVER, (size_t) 0, (dvoid **) 0))
{
  printf("FAILED: OCIHandleAlloc() on srvhp\n");
  return OCI_ERROR;
}
/* Allocate service context handle */
if (status = OCIHandleAlloc((dvoid *) ctx->envhp,
                            (dvoid **) &(ctx->svchp), (ub4) OCI_HTYPE_SVCCTX,
                            (size_t) 0, (dvoid **) 0))
{
  printf("FAILED: OCIHandleAlloc() on svchp\n");
  return OCI_ERROR;
}
/* Allocate session handle */
if (status = OCIHandleAlloc((dvoid *) ctx->envhp, (dvoid **) &ctx->sesshp ,
                         (ub4) OCI_HTYPE_SESSION, (size_t) 0, (dvoid **) 0))
{
  printf("FAILED: OCIHandleAlloc() on sesshp\n");
  return OCI_ERROR;
}
/* Allocate statement handle */
if (OCIHandleAlloc((dvoid *)ctx->envhp, (dvoid **) &ctx->stmthp,
                   (ub4)OCI_HTYPE_STMT, (CONST size_t) 0, (dvoid **) 0))
{
  printf("FAILED: OCIHandleAlloc() on stmthp\n");
  return status;
}
if (status = OCIServerAttach((OCIServer *) ctx->srvhp, (OCIError *) ctx->errhp,
                             (CONST oratext *)"", 0, (ub4) OCI_DEFAULT))
{
  printf("FAILED: OCIServerAttach() on srvhp\n");
  return OCI_ERROR;
}
/* Set server attribute to service context */
if (status = OCIAttrSet((dvoid *) ctx->svchp, (ub4) OCI_HTYPE_SVCCTX,
                        (dvoid *) ctx->srvhp, (ub4) 0, (ub4) OCI_ATTR_SERVER,
                        (OCIError *) ctx->errhp))
{
  printf("FAILED: OCIAttrSet() on svchp\n");
  return OCI_ERROR;
}
/* Set user attribute to session */
if (status = OCIAttrSet((dvoid *)ctx->sesshp, (ub4) OCI_HTYPE_SESSION,
                        (dvoid *)ctx->username,
```

```
                          (ub4) strlen((char *)ctx->username),
                          (ub4) OCI_ATTR_USERNAME, (OCIError *) ctx->errhp))
  {
    printf("FAILED: OCIAttrSet() on authp for user\n");
    return OCI_ERROR;
  }
  /* Set password attribute to session */
  if (status = OCIAttrSet((dvoid *) ctx->sesshp, (ub4) OCI_HTYPE_SESSION,
                          (dvoid *)ctx->password,
                          (ub4) strlen((char *)ctx->password),
                          (ub4) OCI_ATTR_PASSWORD, (OCIError *) ctx->errhp))
  {
    printf("FAILED: OCIAttrSet() on authp for password\n");
    return OCI_ERROR;
  }
  /* Begin a session  */
  if (status = OCISessionBegin((OCISvcCtx *) ctx->svchp,
                               (OCIError *) ctx->errhp,
                               (OCISession *) ctx->sesshp, (ub4) OCI_CRED_RDBMS,
                               (ub4) OCI_STMT_CACHE))
  {
    printf("FAILED: OCISessionBegin(). Make sure database is up and the \
            username/password is valid. \n");
    return OCI_ERROR;
  }
  /* Set session attribute to service context */
  if (status = OCIAttrSet((dvoid *) ctx->svchp, (ub4) OCI_HTYPE_SVCCTX,
                          (dvoid *)ctx->sesshp, (ub4) 0, (ub4) OCI_ATTR_SESSION,
                          (OCIError *) ctx->errhp))
  {
    printf("FAILED: OCIAttrSet() on svchp\n");
    return OCI_ERROR;
  }
  return status;
}

/* Helper function 3: Free OCI handles and disconnect */
static sword free_oci_handles(test_ctx *ctx)
{
  sword  status = 0;
  /* End the session */
  if (status = OCISessionEnd((OCISvcCtx *)ctx->svchp, (OCIError *)ctx->errhp,
                             (OCISession *)ctx->sesshp, (ub4) OCI_DEFAULT))
  {
    if (ctx->envhp)
      OCIHandleFree((dvoid *)ctx->envhp, OCI_HTYPE_ENV);
    return status;
  }
  /* Detach from the server */
  if (status = OCIServerDetach((OCIServer *)ctx->srvhp, (OCIError *)ctx->errhp,
      (ub4)OCI_DEFAULT))
  {
    if (ctx->envhp)
      OCIHandleFree((dvoid *)ctx->envhp, OCI_HTYPE_ENV);
    return status;
  }
  /* Free the handles */
  if (ctx->stmthp) OCIHandleFree((dvoid *)ctx->stmthp, (ub4) OCI_HTYPE_STMT);
  if (ctx->sesshp) OCIHandleFree((dvoid *)ctx->sesshp, (ub4) OCI_HTYPE_SESSION);
  if (ctx->svchp)  OCIHandleFree((dvoid *)ctx->svchp,  (ub4) OCI_HTYPE_SVCCTX);
```

```
  if (ctx->srvhp)  OCIHandleFree((dvoid *)ctx->srvhp,  (ub4) OCI_HTYPE_SERVER);
  if (ctx->errhp)  OCIHandleFree((dvoid *)ctx->errhp,  (ub4) OCI_HTYPE_ERROR);
  if (ctx->envhp)  OCIHandleFree((dvoid *)ctx->envhp,  (ub4) OCI_HTYPE_ENV);
  return status;
}
```

B

Oracle XML DB Restrictions

This appendix describes the restrictions associated with Oracle XML DB.

- *Thin JDBC Driver Not Supported by Some XMLType Functions* – `XMLType` methods `createXML()` with a stream argument, `extract()`, `transform()`, and `existsNode()` work only with the OCI driver. Not all `oracle.xdb.XMLType` functions are supported by the thin JDBC driver. If you do not use `oracle.xdb.XMLType` classes and the OCI driver, you can lose performance benefits.
- *NCHAR, NVARCHAR2, and NCLOB Not Supported* – Oracle XML DB does not support the use of SQL data types `NCHAR`, `NVARCHAR2`, and `NCLOB` for any of the following:
  - Mapping XML elements or attributes to these data types using the `SQLType` annotation in an XML schema
  - Generating XML data from these data types using SQL/XML functions `XMLElement`, `XMLAttributes`, and `XMLForest`
  - Within SQL/XML functions `XMLQuery` and `XMLTable`, using XQuery functions `ora:view` (deprecated), `fn:doc`, and `fn:collection` on tables that contain columns with these data types

  To handle, store, or generate XML data that contains multibyte characters, Oracle strongly recommends that you use AL32UTF8 as the database character set.
- *XML Identifier Length Limit* – Oracle XML DB supports only XML identifiers that are a maximum of 32767 bytes or 4000 bytes, depending on the value of initialization parameter `MAX_STRING_SIZE`. See *Oracle Database SQL Language Reference*.
- *Repository File Size Limit* – The maximum size of a file in Oracle XML DB Repository is 4 gigabytes. This implies the following limits for different kinds of file data:
  - 4 gigabytes for any LOB, which means 2 gigacharacters for a `CLOB` stored in the database character set AL32UTF8.
  - 4 gigabytes for binary XML encoded data, which typically means more than 4 gigabytes of external XML data before encoding.
  - Indeterminate for XML data stored object-relationally.
- *Repository-Wide Resource Configuration File Limit* – You cannot create more than 125 resource configuration files for repository-wide configuration.
- *Recursive Folder Deletion* – You cannot delete more than 50 levels of nested folders using the option for recursive deletion.

- *No Hybrid Columnar Compression* – Hybrid columnar compression, which is available only for Oracle Exadata Storage Server Software, cannot be used with an `XMLType` column that is stored object-relationally or with an `XMLType` table (no matter which storage model is used). `XMLType` supports only basic compression and compression for OLTP.
- *No Column-Level Encryption for `XMLType`* – Column-level encryption is not supported for `XMLType`. Tablespace-level encryption is supported for all `XMLType` storage models.
- *No Composite Partitioning for XMLType* – Composite partitioning is not supported for `XMLType` tables or columns (regardless of the `XMLType` storage model).
- *No Partitioning for Hierarchically Enabled Tables* – You cannot partition a hierarchy-enabled table. (See "Repository Resources and Database Table Security" on page 27-17 for information about hierarchy-enabled tables.
- *No Oracle Real Application Testing (RAT) for XMLType* – Oracle Real Application Testing (RAT) is not supported for `XMLType`.
- *No `XMLType` Access over Database Links* – Access to remote `XMLType` tables or columns is not supported.
- *Oracle JVM Needed for Some Features* – In general, the behavior of Oracle XML DB does not depend on whether or not you have Oracle JVM (Java Virtual Machine) installed. However, if you use Java servlets or PL/SQL package `DBMS_XMLSAVE` or `DBMS_XMLQUERY` then you must install Oracle JVM.
- *Editioning Views Not Compatible with XMLType* – Editioning views are not compatible with `XMLType` data that is stored object-relationally. They cannot be enabled in database schemas that contain persisted object types.
- *Transportable tablespaces and database consolidation* – If your Oracle XML DB Repository in Oracle Database 11*g* Release 2 (11.2) has existing data then you cannot use transportable tablespaces to plug that database directly into a container database (CDB). Instead, upgrade the 11.2 database to 12.1, unplug it, and then plug it in.

See Also:

- "Oracle XML DB Support for XQuery" on page 4-25 for information about Oracle XML DB support for XQuery
- *Oracle Exadata Storage Server Software User's Guide* for information about Oracle Exadata Storage Server

C

Deprecated Functions for Updating XML Data

This appendix describes Oracle SQL functions for updating XML data that are *deprecated* starting with Oracle Database 12*c* Release 1 (12.1.0.1). Use XQuery Update instead to update XML data (see Chapter 4, "XQuery and Oracle XML DB").

This appendix contains these topics:

Migration from Oracle Functions for Updating XML Data to XQuery Update

The XQuery Update Facility 1.0 Recommendation is supported by Oracle XML DB starting with Oracle Database 12c Release 1 (12.1.0.1). Prior to this release, to update XML data your queries necessarily used Oracle-specific SQL functions: `appendChildXML`, `deleteXML`, `insertChildXML`, `insertchildXMLafter`, `insertChildXMLbefore`, `insertXMLafter`, `insertXMLbefore`, and `updateXML`. These functions are covered in detail in the other sections of this appendix.

If you have legacy code that uses these functions, Oracle recommends that you migrate that code to use XQuery Update. This section provides information about which XQuery Update constructs you can use to replace the use of the Oracle-specific XML updating functions in queries.

Table C–1 provides a mapping from typical queries that use Oracle-specific updating SQL functions to queries that use XQuery Update.

Note that there is no Oracle-specific equivalent for the XQuery Update constructs `rename` and `insert as first into`.

Note too that if the target XPath expression matches more than one node then the Oracle updating functions act on *all* such nodes, whereas the XQuery Update functions raise an error in this case. To act on multiple nodes using XQuery Update you need to use explicit iteration (that is, a `for` expression).

Table C–1 Migrating Oracle-Specific XML Updating Queries to XQuery Update

Original Expression	Replacement Expression

`-- Insert a node as the last child of a node.`
`UPDATE warehouses SET warehouse_spec =`
`  appendChildXML(`
`  warehouse_spec,`
`  '/Warehouse/Parking',`
`  XMLType('<Spaces>250</Spaces>'));`
	`-- Insert a node as the last child of a node.`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := . modify insert node`
	`  <Spaces>250</Spaces>`
	`  as last into $tmp/Warehouse/Parking`
	`  return $tmp'`
	`  PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Delete a node.`
`UPDATE warehouses SET warehouse_spec =`
`  deleteXML(value(po), '/Warehouse/VClearance');`
	`-- Delete a node.`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := . modify delete node`
	`  $tmp/Warehouse/VClearance return $tmp'`
	`  PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Insert a node as a child of a node.`
`UPDATE warehouses SET warehouse_spec =`
`  insertChildXML(`
`  warehouse_spec,`
`  '/Warehouse/Parking',`
`  'Spaces',`
`  XMLType('<Spaces>300</Spaces>');`
	`-- Insert a node as a child of a node.`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := . modify insert node`
	`  <Spaces>300</Spaces>`
	`  into $tmp/Warehouse/Parking`
	`  return $tmp'`
	`  PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Insert a node before a node.`
`UPDATE warehouses SET warehouse_spec =`
`  insertXMLbefore(`
`  warehouse_spec,`
`  '/Warehouse/RailAccess',`
`  XMLType('<SkyAccess>N</SkyAccess>');`
	`-- Insert a node before a node.`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := . modify insert node`
	`  <SkyAccess>N</SkyAccess>`
	`  before $tmp/Warehouse/RailAccess`
	`  return $tmp'`
	`  PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Insert a node after a node.`
`UPDATE warehouses SET warehouse_spec =`
`  insertXMLafter(`
`  warehouse_spec,`
`  '/Warehouse/RailAccess',`
`  XMLType('<SkyAccess>N</SkyAccess>');`
	`-- Insert a node after a node.`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := . modify insert node`
	`  <SkyAccess>N</SkyAccess>`
	`  after $tmp/Warehouse/RailAccess`
	`  return $tmp'`
	`  PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Replace the text value of a set of nodes.`
`-- (Assumes a collection of <Building> nodes.)`
`UPDATE warehouses SET warehouse_spec =`
`  updateXML(warehouse_spec,`
`  '/Warehouse/Building/text()',`
`  'Owned');`
	`-- Replace the text value of a set of nodes.`
	`-- (Assumes a collection of <Building> nodes.)`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := . modify`
	`  (for $i in $tmp/Warehouse/Building/text()`
	`  return replace value of node $i`
	`  with ''Owned'')`
	`  return $tmp'`
	`  PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

Table C–1 (Cont.) Migrating Oracle-Specific XML Updating Queries to XQuery Update

Original Expression	Replacement Expression

`-- Insert a child under each node in a collection.`
`-- (Assumes a collection of <Building> nodes.)`
`UPDATE warehouses SET warehouse_spec =`
`  insertChildXML(`
`    warehouse_spec,`
`    '/Warehouse/Building',`
`    'Owner',`
`    XMLType('<Owner>LesserCo</Owner>'));`
	`-- Insert a child under each node in a collection.`
	`-- (Assumes a collection of <Building> nodes.)`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := . modify`
	`           (for $i in $tmp/Warehouse/Building`
	`            return insert node`
	`            <Owner>LesserCo</Owner>`
	`            into $i)`
	`           return $tmp'`
	`          PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Insert as child before the other children.`
`-- (Assumes a collection of <Owner> nodes.)`
`UPDATE warehouses SET warehouse_spec =`
`  insertChildXMLbefore(`
`    warehouse_spec,`
`    '/Warehouse/Building[1]',`
`    'Owner',`
`    XMLType('<Owner>LesserCo</Owner>'));`
	`-- Insert as child before the other children.`
	`-- (Assumes a collection of <Owner> nodes.)`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery(`
	`    'copy $tmp := . modify`
	`     (for $i in $tmp/Warehouse/Building[1]/Owner`
	`      return insert node <Owner>LesserCo</Owner>`
	`             before $i)`
	`     return $tmp'`
	`    PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Insert as child after the other children.`
`-- (Assumes a collection of <Owner> nodes.)`
`UPDATE warehouses SET warehouse_spec =`
`  insertChildXMLafter(`
`    warehouse_spec,`
`    '/Warehouse/Building[1]',`
`    'Owner',`
`    XMLType('<Owner>LesserCo</Owner>'));`
	`-- Insert as child after the other children.`
	`-- (Assumes a collection of <Owner> nodes.)`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery(`
	`    'copy $tmp := . modify`
	`     (for $i in $tmp/Warehouse/Building[1]/Owner`
	`      return insert node <Owner>LesserCo</Owner>`
	`             after $i)`
	`     return $tmp'`
	`    PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Delete a node.`
`UPDATE warehouses SET warehouse_spec =`
`  updateXML(warehouse_spec,`
`            '/Warehouse/Docks',`
`            NULL);`
	`-- Delete a node.`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := . modify delete node`
	`           $tmp/Warehouse/Docks return $tmp'`
	`          PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Replace with an empty node.`
`UPDATE warehouses SET warehouse_spec =`
`  updateXML(warehouse_spec, '/Warehouse/Docks', '' );`
	`-- Replace with an empty node.`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery('copy $tmp := $p1 modify`
	`           (for $j in $tmp/Warehouse/Docks`
	`            return replace node $j with $p2)`
	`           return $tmp'`
	`          PASSING warehouse_spec "p1", '' AS "p2"`
	`          RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

`-- Update multiple paths.`
`UPDATE warehouses SET warehouse_spec =`
`  updateXML(warehouse_spec,`
`            '/Warehouse/Docks/text()', '4',`
`            '/Warehouse/Area/text()', '3500');`
	`-- Update multiple paths.`
	`UPDATE warehouses SET warehouse_spec =`
	`  XMLQuery(`
	`    'copy $tmp := . modify`
	`     ((for $i in $tmp/Warehouse/Docks/text()`
	`       return replace value of node $i with 4),`
	`      (for $i in $tmp/Warehouse/Area/text()`
	`       return replace value of node $i with 3500))`
	`     return $tmp'`
	`    PASSING warehouse_spec RETURNING CONTENT)`
	`  WHERE warehouse_spec IS NOT NULL;`

Deprecated Oracle SQL Functions for Updating XML Data

Prior to their deprecation, you used the following Oracle SQL functions to update XML data incrementally—that is, to replace, insert, or delete XML data without replacing the entire surrounding XML document. This is also called **partial updating**. The Oracle SQL functions are described in the following sections:

- `updateXML` – Replace XML nodes of any kind. See "UPDATEXML Deprecated Oracle SQL Function" on page C-6.
- `insertChildXML` – Insert XML element or attribute nodes as children of a given element node. See "INSERTCHILDXML Deprecated Oracle SQL Function" on page C-15.
- `insertChildXMLbefore` – Insert new collection elements immediately before a given collection element of the same type. See "INSERTCHILDXMLBEFORE Deprecated Oracle SQL Function" on page C-17.
- `insertChildXMLafter` – Insert new collection elements immediately after a given collection element of the same type. See "INSERTCHILDXMLAFTER Deprecated Oracle SQL Function" on page C-18.
- `insertXMLbefore` – Insert XML nodes of any kind immediately before a given node (other than an attribute node). See "INSERTXMLBEFORE Deprecated Oracle SQL Function" on page C-19.
- `insertXMLafter` – Insert XML nodes of any kind immediately after a given node (other than an attribute node). See "INSERTXMLAFTER Deprecated Oracle SQL Function" on page C-21.
- `appendChildXML` – Insert XML nodes of any kind as the last child nodes of a given element node. See "APPENDCHILDXML Deprecated Oracle SQL Function" on page C-22.
- `deleteXML` – Delete XML nodes of any kind. See "DELETEXML Deprecated Oracle SQL Function" on page C-23.

Functions `insertChildXML`, `insertChildXMLbefore`, `insertChildXMLafter`, `insertXMLbefore`, `insertXMLafter`, and `appendChildXML` are for inserting XML data. Function `deleteXML` deletes XML data. Function `updateXML` replaces XML data.

In particular, do *not* use function `updateXML` to insert or delete XML data by replacing a parent node in its entirety. That works, but it is less efficient than using one of the other functions, which perform more localized updates.

These Oracle SQL functions do *not*, by themselves, change database data – they are all pure functions, without side effect. Each applies an XPath-expression argument to input XML data and returns a modified *copy* of the input XML data. You can then use that result with SQL DML operator `UPDATE` to modify database data. This is no different from the way you use SQL function `upper` to convert database data to uppercase: you must use a SQL DML operator such as `UPDATE` to change the stored data.

Each of these functions can be used on XML documents that are either schema-based or non-schema-based. For XML schema-based data, these Oracle SQL functions perform partial validation on the result, and, where appropriate, argument values are also checked for compatibility with the XML schema.

Note: Oracle SQL functions and `XMLType` methods respect the W3C XPath recommendation, which states that if an XPath expression targets *no nodes* when applied to XML data, then an empty sequence must be returned. An error must *not* be raised in this case.

The specific semantics of an Oracle SQL function or `XMLType` method that applies an XPath expression to XML data determines what is returned. For example, SQL/XML function `XMLQuery` returns `NULL` if its XPath-expression argument targets no nodes, and the deprecated updating Oracle SQL functions, such as `deleteXML`, return the input XML data unchanged. An error is never raised if no nodes are targeted, but the deprecated updating Oracle SQL functions can raise an error if an XPath-expression argument targets inappropriate nodes, such as attribute nodes or text nodes.

See Also: "Partial and Full XML Schema Validation" on page 7-12 for more information about partial validation against an XML schema

Insertion of XML Elements Using Deprecated Oracle SQL Functions

There are several deprecated Oracle SQL functions for inserting XML nodes into (a copy of) existing XML data. Each can insert nodes at multiple locations that are referenced by an XPath expression. They differ in the placement of the new nodes and how the target XML data is referenced.

- Function `appendChildXML` appends nodes to the target elements. That is, for each target element, it inserts one or more nodes of any kind as the element's last children.
- Function `insertChildXML` inserts new children (one or more elements of the same type or a single attribute) under target elements. The position of a new child element under its parent is not specified. If the target data is XML schema-based, then the schema can sometimes be used to determine the position. Otherwise, the position is arbitrary.
- Function `insertXMLbefore` inserts one or more nodes of *any kind* immediately before a target node (which is not an attribute node).

  Function `insertXMLafter` inserts a node similarly, but after the target, not before.
- Function `insertChildXMLbefore` is similar to `insertChildXML`, except that the inserted node must be an element (not an attribute), and you specify the position of the new element among its siblings. It is similar to `insertXMLbefore`, except that it inserts only *collection* elements, not arbitrary elements. The insertion position specifies a successor collection member. The actual element to be inserted must correspond to the element type for the collection.

  Function `insertChildXMLafter` inserts a node similarly, but after the target, not before.

Though the effect of `insertChildXMLbefore` (`-after`) is similar to that of `insertXMLbefore` (`-after`), the target location is expressed differently. For the former, the target is the parent of the new child. For the latter, the target is the succeeding (or preceding) sibling. This difference is reflected in the function names (`Child`).

For example, to insert a new `LineItem` element before the third `LineItem` element under element `/PurchaseOrder/LineItems`, you can use `insertChildXMLbefore`, specifying the target parent as `/PurchaseOrder/LineItems` and the succeeding sibling

as `LineItem[3]`. Or you can use `insertXMLbefore`, specifying the target succeeding sibling as `/PurchaseOrder/LineItems/LineItem[3]`. If you use `insertChildXML` for the insertion, then you cannot specify the position of the new element in the collection—the resulting position is indeterminate.

Another difference among these functions is that all of them *except* `insertXMLbefore`, `insertXMLafter`, and `appendChildXML`—are optimized for SQL `UPDATE` operations on `XMLType` tables and columns that are stored object-relationally or as binary XML.

> **See Also:** "Optimization of Deprecated Oracle SQL Functions that Modify XML Data" on page C-12

UPDATEXML Deprecated Oracle SQL Function

Deprecated Oracle SQL function `updateXML` replaces XML nodes of any kind. The XML document that is the target of the update can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned. The original data is unaffected. You can then use the returned data with SQL operation `UPDATE` to modify database data.

Function `updateXML` has the following parameters (in order):

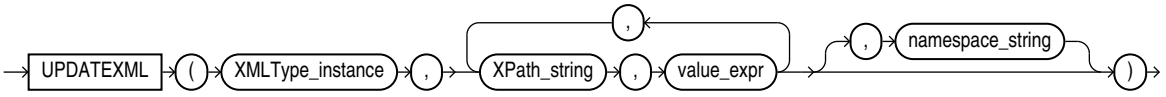
- ***target-data*** (`XMLType`) – The XML data containing the target node to replace.
- One or more *pairs* of *`xpath`* and *`replacement`* parameters:
  - ***xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates the nodes within *`target-data`* to replace. *Each* targeted node is replaced by *`replacement`*. These can be nodes of any kind. If *`xpath`* matches an empty sequence of nodes then no replacement is done, and *`target-data`* is returned unchanged (and no error is raised).
  - ***replacement*** (`XMLType` or `VARCHAR2`) – The XML data that replaces the data targeted by *`xpath`*. The data type of *`replacement`* must correspond to the data to be replaced. If *`xpath`* targets an element node for replacement, then the data type must be `XMLType`. If *`xpath`* targets an attribute node or a text node, then it must be `VARCHAR2`. For an attribute node, *`replacement`* is only the replacement *value* of the attribute (for example, 23), not the complete attribute node including the name (for example, `my_attribute="23"`).
- ***namespace*** (`VARCHAR2`, *optional*) – The XML namespace for parameter *`xpath`*.

Deprecated Oracle SQL function `updateXML` can be used to *replace* existing elements, attributes, and other nodes with new values. It is *not* an efficient way to insert new nodes or delete existing ones. You can perform insertions and deletions with `updateXML` only by using it to replace the entire node that is the parent of the node to be inserted or deleted.

Function `updateXML` updates only the transient XML instance in memory. Use a SQL `UPDATE` statement to update data stored in tables.

Figure C–1 illustrates the syntax.

Figure C–1 UPDATEXML Syntax



Example C–1 uses `updateXML` on the right side of an `UPDATE` statement to update the XML document in a table instead of creating a new document. The entire document is updated, not just the part that is selected.

Example C–1 Updating XMLTYPE Using UPDATE and UPDATEXML (Deprecated)

```
SELECT XMLQuery('$p/PurchaseOrder/Actions/Action[1]' PASSING po.OBJECT_VALUE AS "p"
                                                    RETURNING CONTENT) action
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

ACTION
--------------------------------
<Action>
  <User>SVOLLMAN</User>
</Action>

UPDATE purchaseorder po
  SET po.OBJECT_VALUE = updateXML(po.OBJECT_VALUE,
                                  '/PurchaseOrder/Actions/Action[1]/User/text()',
                                  'SKING')
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

SELECT XMLQuery('$p/PurchaseOrder/Actions/Action[1]' PASSING po.OBJECT_VALUE AS "p"
                                                    RETURNING CONTENT) action
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

ACTION
--------------------------------
<Action>
  <User>SKING</User>
</Action>
```

Example C–2 updates multiple nodes using Oracle SQL function `updateXML`.

Example C–2 Updating Multiple Text Nodes and Attribute Values Using UPDATEXML (Deprecated)

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME            LINEITEMS
--------------- --------------------------------------------------------------------------
Sarah J. Bell   <LineItems>
                  <LineItem ItemNumber="1">
                    <Description>A Night to Remember</Description>
                    <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="2">
                    <Description>The Unbearable Lightness Of Being</Description>
                    <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="3">
```

```
                  <Description>Sisters</Description>
                  <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                </LineItem>
              </LineItems>

UPDATE purchaseorder
  SET OBJECT_VALUE = updateXML(OBJECT_VALUE,
                               '/PurchaseOrder/Requestor/text()','Stephen G. King',
                               '/PurchaseOrder/LineItems/LineItem[1]/Part/@Id','786936150421',
                               '/PurchaseOrder/LineItems/LineItem[1]/Description/text()','The Rock',
                               '/PurchaseOrder/LineItems/LineItem[3]',
                               XMLType('<LineItem ItemNumber="99">
                                          <Description>Dead Ringers</Description>
                                          <Part Id="715515009249" UnitPrice="39.95" Quantity="2"/>
                                        </LineItem>'))
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME             LINEITEMS
---------------- --------------------------------------------------------------------
Stephen G. King  <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>The Rock</Description>
                     <Part Id="786936150421" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="2">
                     <Description>The Unbearable Lightness Of Being</Description>
                     <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="99">
                     <Description>Dead Ringers</Description>
                     <Part Id="715515009249" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                 </LineItems>
```

Example C–3 uses SQL function `updateXML` to update selected nodes within a collection.

Example C–3 Updating Selected Nodes within a Collection Using UPDATEXML (Deprecated)

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME             LINEITEMS
---------------- --------------------------------------------------------------------
Sarah J. Bell    <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>A Night to Remember</Description>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
```

```
                  </LineItem>
                  <LineItem ItemNumber="2">
                    <Description>The Unbearable Lightness Of Being</Description>
                    <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="3">
                    <Description>Sisters</Description>
                    <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                  </LineItem>
                </LineItems>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      updateXML(OBJECT_VALUE,
                '/PurchaseOrder/Requestor/text()','Stephen G. King',
                '/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]/@Quantity',
                25,
                '/PurchaseOrder/LineItems/LineItem[Description/text() =
                                                   "The Unbearable Lightness Of Being"]',
                XMLType('<LineItem ItemNumber="99">
                           <Part Id="786936150421" Quantity="5" UnitPrice="29.95"/>
                           <Description>The Rock</Description>
                         </LineItem>'))
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME             LINEITEMS
---------------- ------------------------------------------------------------
Stephen G. King  <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>A Night to Remember</Description>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity="25"/>
                   </LineItem>
                   <LineItem ItemNumber="99">
                     <Part Id="786936150421" Quantity="5" UnitPrice="29.95"/>
                     <Description>The Rock</Description>
                   </LineItem>
                   <LineItem ItemNumber="3">
                     <Description>Sisters</Description>
                     <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                   </LineItem>
                 </LineItems>
```

Deprecated Oracle SQL Function UPDATEXML and NULL Values

The following considerations apply to using deprecated Oracle SQL function `updateXML` with `NULL` values.

- If you update an XML *element* to `NULL`, the attributes and children of the element are removed, and the element becomes empty. The type and namespace properties of the element are retained. See Example C–4.

- If you update an *attribute* value to NULL, the value appears as the empty string. See Example C–4.
- If you update the *text* node of an element to NULL, the content (text) of the element is removed. The element itself remains, but it is empty. See Example C–5.

Example C–4 updates all of the following to NULL:

- The Description element and the Quantity attribute of the LineItem element whose Part element has attribute Id value 715515009058.
- The LineItem element whose Description element has the content (text) "The Unbearable Lightness Of Being".

Example C–4 NULL Updates with UPDATEXML (Deprecated) – Element and Attribute

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

NAME             LINEITEMS
---------------- --------------------------------------------------------------------
Sarah J. Bell    <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>A Night to Remember</Description>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="2">
                     <Description>The Unbearable Lightness Of Being</Description>
                     <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="3">
                     <Description>Sisters</Description>
                     <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                   </LineItem>
                 </LineItems>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      updateXML(
        OBJECT_VALUE,
        '/PurchaseOrder/LineItems/LineItem[Part/@Id="715515009058"]/Description', NULL,
             '/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]/@Quantity', NULL,
        '/PurchaseOrder/LineItems/LineItem[Description/text()=
                                           "The Unbearable Lightness Of Being"]', NULL)
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Requestor'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(30)) name,
       XMLQuery('$p/PurchaseOrder/LineItems'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT) lineitems
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");
```

```
NAME            LINEITEMS
--------------- ----------------------------------------------------------------
Sarah J. Bell   <LineItems>
                  <LineItem ItemNumber="1">
                    <Description/>
                    <Part Id="715515009058" UnitPrice="39.95" Quantity=""/>
                  </LineItem>
                  <LineItem/>
                  <LineItem ItemNumber="3">
                    <Description>Sisters</Description>
                    <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                  </LineItem>
                </LineItems>
```

Example C–5 updates the text node of a `Part` element whose `Description` attribute has value "`A Night to Remember`" to `NULL`. The XML data for this example corresponds to a different, revised purchase-order XML schema – see "Scenario for Copy-Based Evolution" on page 20-2. In that XML schema, `Description` is an attribute of the `Part` element, not a sibling element.

Example C–5 NULL Updates with UPDATEXML (Deprecated) – Text Node

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(128)) part
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[@Reference="SBELL-2003030912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

PART
----
<Part Description="A Night to Remember" UnitCost="39.95">715515009058</Part>

UPDATE purchaseorder
  SET OBJECT_VALUE =
        updateXML(OBJECT_VALUE,
                  '/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]/text()', NULL)
  WHERE XMLExists('$p/PurchaseOrder[@Reference="SBELL-2003030912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(128)) part
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[@Reference="SBELL-2003030912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

PART
----
<Part Description="A Night to Remember" UnitCost="39.95"/>
```

See Also: Example 3–26, "Updating a Text Node"

Update of the Same XML Node More Than Once Using UPDATEXML (Deprecated)

You can update the same XML node more than once in an `updateXML` expression. For example, you can update both `/EMP[EMPNO=217]` and `/EMP[EMPNAME="Jane"]/EMPNO`, where the first XPath identifies the `EMPNO` node containing it as well. The order of updates is determined by the order of the XPath expressions in left-to-right order. Each successive XPath works on the result of the previous XPath update.

Guidelines for Preserving DOM Fidelity When Using UPDATEXML (Deprecated)

Here are some guidelines for preserving DOM fidelity when using Oracle SQL function `updateXML`:

When DOM Fidelity is Preserved

When you update an element to `NULL`, you make that element appear *empty* in its parent, such as in `<myElem/>`.

When you update a text node inside an element to `NULL`, you *remove* that text node from the element.

When you update an attribute node to `NULL`, you make the value of the attribute become the *empty* string, for example, `myAttr=""`.

When DOM Fidelity is Not Preserved

When you update a `complexType` element to `NULL`, you make the element appear *empty* in its parent, for example, `<myElem/>`.

When you update a SQL-inlined `simpleType` element to `NULL`, you make the element *disappear* from its parent.

When you update a text node to `NULL`, you are doing the same thing as setting the parent `simpleType` element to `NULL`. Furthermore, text nodes can appear only inside `simpleType` elements when DOM fidelity is not preserved, since there is no positional descriptor with which to store mixed content.

When you update an attribute node to `NULL`, you *remove* the attribute from the element.

How to Tell Whether DOM Fidelity is Preserved

You can determine whether or not DOM fidelity is preserved for particular parts of a given `XMLType` in a given XML schema by querying the schema metadata for attribute `maintainDOM`.

See Also:

- "Querying a Registered XML Schema to Obtain Annotations" on page 18-16 for an example of querying a schema to retrieve DOM fidelity values
- "DOM Fidelity" on page 17-6

Optimization of Deprecated Oracle SQL Functions that Modify XML Data

In most cases, the deprecated Oracle SQL functions that modify XML data materialize a copy of the entire input XML document in memory, then update the copy. However, functions `updateXML`, `insertChildXML`, `insertChildXMLbefore`, `insertChildXMLafter`, and `deleteXML`—that is, all *except* `insertXMLbefore`, `insertXMLafter`, and `appendChildXML`—are optimized for SQL `UPDATE` operations on `XMLType` tables and columns that are stored object-relationally or as binary XML.

For object-relational storage, if particular conditions are met, then the function call can be rewritten to update the object-relational columns directly with the values. For binary XML storage, data preceding the targeted update is not modified, and, if SecureFiles LOBs are used (the default behavior), then sliding inserts are used to update only the portions of the data that need changing.

See Also:

- Chapter 3, "Overview of How To Use Oracle XML DB" and Chapter 19, "XPath Rewrite for Object-Relational Storage" for information about the conditions for XPath rewrite
- "Performance Tuning for XQuery" on page 5-39

As an example with object-relational storage, the XPath argument to `updateXML` in Example C–6 is processed by Oracle XML DB and rewritten into equivalent object-relational SQL code, as illustrated in Example C–7.

Example C–6 XPath Expressions in UPDATEXML Expression

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/User'
PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
       AS VARCHAR2(30))
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
  PASSING po.OBJECT_VALUE AS "p");

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
SBELL

UPDATE purchaseorder
  SET OBJECT_VALUE = updateXML(OBJECT_VALUE, '/PurchaseOrder/User/text()', 'SVOLLMAN')
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
  PASSING OBJECT_VALUE AS "p");

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/User'
PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
       AS VARCHAR2(30))
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
  PASSING po.OBJECT_VALUE AS "p");

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
SVOLLMAN
```

Example C–7 Object Relational Equivalent of UPDATEXML Expression

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/User'
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS VARCHAR2(30))
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
SBELL

UPDATE purchaseorder p
   SET p."XMLDATA"."USERID" = 'SVOLLMAN'
   WHERE p."XMLDATA"."REFERENCE" = 'SBELL-2002100912333601PDT';

SELECT XMLCast(XMLQuery('$p/PurchaseOrder/User'
```

```
                        PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(30))
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");


XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
SVOLLMAN
```

> **Note:** The use of `XMLDATA` for DML is shown here only as an illustration of internal Oracle XML DB behavior. Do *not* use `XMLDATA` yourself for DML operations. You can use `XMLDATA` directly only for DDL operations, never for DML operations.
>
> More generally, in your code, do not rely on the current mapping between the XML Schema object model and the SQL object model. This Oracle XML DB implementation mapping might change in the future.

Creating XML Views Using Deprecated Oracle SQL Functions that Modify XML Data

You can use the deprecated Oracle SQL functions that modify XML data (`updateXML`, `insertChildXML`, `insertChildXMLbefore`, `insertChildXMLafter`, `insertXMLbefore`, `insertXMLafter`, `appendChildXML`, and `deleteXML`) to create new views of XML data.

Example C–8 creates a view of table `purchaseorder` using deprecated Oracle SQL function `updateXML`.

Example C–8 Creating a View Using UPDATEXML (Deprecated)

```
CREATE OR REPLACE VIEW purchaseorder_summary OF XMLType AS
  SELECT updateXML(OBJECT_VALUE,
                   '/PurchaseOrder/Actions', NULL,
                   '/PurchaseOrder/ShippingInstructions', NULL,
                   '/PurchaseOrder/LineItems', NULL) AS XML
  FROM purchaseorder p;

SELECT OBJECT_VALUE FROM purchaseorder_summary
  WHERE XMLExists('$p/PurchaseOrder[Reference="DAUSTIN-20021009123335811PDT"]'
                  PASSING OBJECT_VALUE AS "p");

OBJECT_VALUE
--------------------------------------------------------------------------------
<PurchaseOrder
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation=
      "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
  <Reference>DAUSTIN-20021009123335811PDT</Reference>
  <Actions/>
  <Reject/>
  <Requestor>David L. Austin</Requestor>
  <User>DAUSTIN</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions/>
  <SpecialInstructions>Courier</SpecialInstructions>
```

```
  <LineItems/>
</PurchaseOrder>
```

INSERTCHILDXML Deprecated Oracle SQL Function

Deprecated Oracle SQL function `insertChildXML` inserts new children (one or more elements of the same type or a single attribute) under parent XML elements. The XML document that is the target of the insertion can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned. The original data is unaffected. You can then use the returned data with SQL operation `UPDATE` to modify database data.

Function `insertChildXML` has the following parameters (in order):

- ***target-data*** (`XMLType`) – The XML data containing the target parent element.
- ***parent-xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates the parent elements within *target-data*. The *child-data* is inserted under *each* parent element.

  If *parent-xpath* matches an empty sequence of element nodes, then no insertion is done, and *target-data* is returned unchanged (no error is raised). If *parent-xpath* does not match a sequence of element nodes (in particular, if *parent-xpath* matches one or more *attribute* or *text* nodes), then an error is raised.
- ***child-name*** (`VARCHAR2`) – The name of the child elements or attribute to insert. An attribute name is distinguished from an element name by having an at-sign (`@`) prefix as part of *child-name*, for example, `@my_attribute` versus `my_element`. (The at-sign is not part of the attribute name, but serves in the argument to indicate that *child-name* refers to an attribute.)
- ***child-data*** (`XMLType` or `VARCHAR2`) – The child XML data to insert:
  - If one or more *elements* are being inserted, then this is of data type `XMLType`, and it contains element nodes. *Each* of the top-level element nodes in *child-data* must have the same name (tag) as *child-name* (or else an error is raised).
  - If an *attribute* is being inserted, then this is of data type `VARCHAR2`, and it represents the (scalar) attribute value. If an attribute of the same name already exists at the insertion location, then an error is raised.
- ***namespace*** (`VARCHAR2`, *optional*) – The XML namespace for parameters *parent-xpath* and *child-data*.

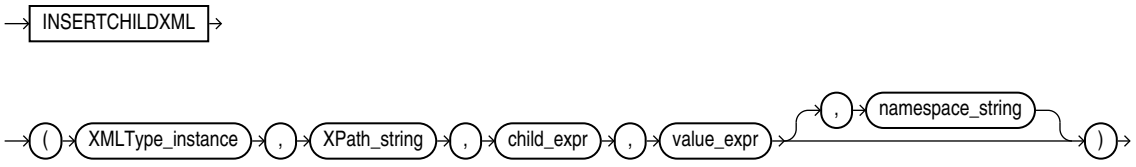
XML data *child-data* is inserted as one or more child elements, or a single child attribute, under *each* of the parent elements located at *parent-xpath*.

In order of decreasing precedence, function `insertChildXML` has the following behavior for `NULL` arguments:

- If *child-name* is `NULL`, then an error is raised.
- If *target-data* or *parent-xpath* is `NULL`, then `NULL` is returned.
- If *child-data* is `NULL`, then:
  - If *child-name* names an element, then no insertion is done, and *target-data* is returned unchanged.
  - If *child-name* names an attribute, then an empty attribute value is inserted, for example, `my_attribute = ""`.

Figure C–2 shows the syntax.

Figure C–2 INSERTCHILDXML Syntax



If *target-data* is XML *schema-based*, then the schema is consulted to determine the insertion positions. For example, if the schema constrains child elements named *child-name* to be the first child elements of a *parent-xpath*, then the insertion takes this into account. Similarly, if the *child-name* or *child-data* argument is inappropriate for an associated schema, then an error is raised.

If the parent element does *not* yet have a child corresponding in name and kind to *child-name* (and if such a child is permitted by the associated XML schema, if any), then *child-data* is inserted as new child elements, or a new attribute value, named *child-name*.

If the parent element already has a child *attribute* named *child-name* (without the at-sign), then an error is raised. If the parent element already has a child *element* named *child-name* (and if more than one child element is permitted by the associated XML schema, if any), then *child-data* is inserted so that its elements become child elements named *child-name*, but their positions in the sequence of children are unpredictable.

If you need to insert elements into an existing, non-empty collection of child elements, and the order is important to you, then use SQL/XML function `appendChildXML` or `insertXMLbefore`.

Example C–9 shows how to use a SQL `UPDATE` statement and Oracle SQL function `insertChildXML` to insert a new `LineItem` element as a child of element `LineItems`.

Example C–9 Insertion into a Collection Using INSERTCHILDXML (Deprecated)

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[@ItemNumber=222]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER=222]'
----------------------------------------------------------------

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
        insertChildXML(OBJECT_VALUE,
                       '/PurchaseOrder/LineItems',
                       'LineItem',
                       XMLType('<LineItem ItemNumber="222">
                                  <Description>The Harder They Come</Description>
                                  <Part Id="953562951413"
                                        UnitPrice="22.95"
                                        Quantity="1"/>
                                </LineItem>'))
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
```

```
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[@ItemNumber=222]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER=222]'
--------------------------------------------------------------
<LineItem ItemNumber="222">
  <Description>The Harder They Come</Description>
  <Part Id="953562951413" UnitPrice="22.95" Quantity="1"/>
</LineItem>

1 row selected.
```

If the XML data to be updated is XML schema-based and it refers to a namespace, then the data to be inserted must also refer to the same namespace. Otherwise, an error is raised because the inserted data does not conform to the XML schema.

Example C–10 is the same as Example C–9, except that the `LineItem` element to be inserted refers to a namespace. This assumes that the relevant XML schema requires a namespace for this element.

Example C–10 Inserting an Element that Uses a Namespace

```
UPDATE purchaseorder
  SET OBJECT_VALUE =
        insertChildXML(OBJECT_VALUE,
                       '/PurchaseOrder/LineItems',
                       'LineItem',
                       XMLType('<LineItem xmlns="films.xsd" ItemNumber="222">
                                  <Description>The Harder They Come</Description>
                                  <Part Id="953562951413"
                                        UnitPrice="22.95"
                                        Quantity="1"/>
                                </LineItem>'))
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING OBJECT_VALUE AS "p");
```

Note that this use of namespaces is different from the use of a namespace *argument* to function `insertChildXML`. Namespaces supplied in that optional argument apply only to the XPath argument, not to the content to be inserted.

INSERTCHILDXMLBEFORE Deprecated Oracle SQL Function

Deprecated Oracle SQL function `insertChildXMLbefore` inserts one or more collection elements as children of target parent elements. The insertion for each target occurs immediately before a specified existing collection element. The existing XML document that is the target of the insertion can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned. The original data is unaffected. You can then use the returned data with SQL operation `UPDATE` to modify database data.

Function `insertChildXMLbefore` has the following parameters (in order):

- ***target-data*** (`XMLType`) – The XML data that is the target of the insertion.

- ***parent-xpath*** (VARCHAR2) – An XPath 1.0 expression that locates the parent elements within *target-data*. The *child-data* is inserted under *each* parent element.

  If *parent-xpath* matches an empty sequence of element nodes, then no insertion is done, and *target-data* is returned unchanged (no error is raised). If *parent-xpath* does not match a sequence of element nodes (in particular, if *parent-xpath* matches one or more *attribute* or *text* nodes), then an error is raised.

- ***child-xpath*** (VARCHAR2) – A relative XPath 1.0 expression that locates the existing child that will become the successor of the inserted *child-data*. It must name a child element of the element indicated by *parent-xpath*, and it can include a predicate.

- ***child-data*** (XMLType) – The child element XML data to insert. This is of data type XMLType, and it contains element nodes. *Each* of the top-level element nodes in *child-data* must have the same data type as the element indicated by *child-xpath* (or else an error is raised).

- ***namespace*** (*optional*, VARCHAR2) – The namespace for parameters *parent-xpath*, *child-xpath*, and *child-data*.

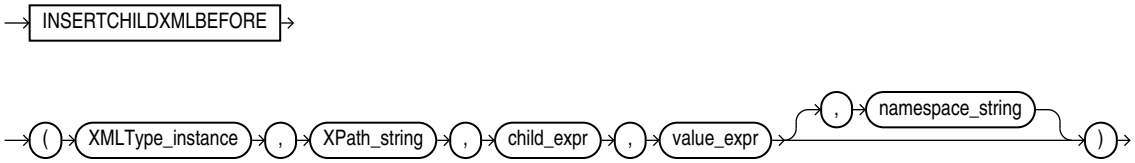
XML data *child-data* is inserted as one or more child elements under *each* of the parent elements located at *parent-xpath*.

In order of decreasing precedence, function insertChildXMLbefore has the following behavior for NULL arguments:

- If *child-xpath* is NULL, then an error is raised.
- If *target-data* or *parent-xpath* is NULL, then NULL is returned.
- If *child-data* is NULL, then no insertion is done, and *target-data* is returned unchanged.

Figure C–3 shows the syntax.

Figure C–3 INSERTCHILDXMLBEFORE Syntax



INSERTCHILDXMLAFTER Deprecated Oracle SQL Function

Deprecated Oracle SQL function insertChildXMLafter inserts one or more collection elements as children of target parent elements. The insertion for each target occurs immediately after a specified existing collection element. The existing XML document that is the target of the insertion can be schema-based or non-schema-based.

A *copy* of the input XMLType instance is modified and returned. The original data is unaffected. You can then use the returned data with SQL operation UPDATE to modify database data.

Function insertChildXMLafter has the following parameters (in order):

- ***target-data*** (XMLType) – The XML data that is the target of the insertion.

- ***parent-xpath*** (VARCHAR2) – An XPath 1.0 expression that locates the parent elements within *target-data*. The *child-data* is inserted under *each* parent element.

  If *parent-xpath* matches an empty sequence of element nodes, then no insertion is done, and *target-data* is returned unchanged (no error is raised). If *parent-xpath* does not match a sequence of element nodes (in particular, if *parent-xpath* matches one or more *attribute* or *text* nodes), then an error is raised.

- ***child-xpath*** (VARCHAR2) – A relative XPath 1.0 expression that locates the existing child that will become the predecessor of the inserted *child-data*. It must name a child element of the element indicated by *parent-xpath*, and it can include a predicate.

- ***child-data*** (XMLType) – The child element XML data to insert. This is of data type XMLType, and it contains element nodes. *Each* of the top-level element nodes in *child-data* must have the same data type as the element indicated by *child-xpath* (or else an error is raised).

- ***namespace*** (*optional*, VARCHAR2) – The namespace for parameters *parent-xpath*, *child-xpath*, and *child-data*.

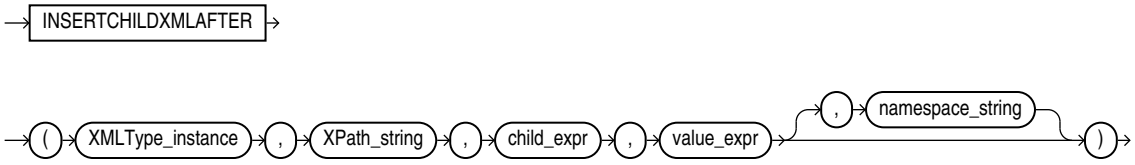
XML data *child-data* is inserted as one or more child elements under *each* of the parent elements located at *parent-xpath*.

In order of decreasing precedence, function insertChildXMLafter has the following behavior for NULL arguments:

- If *child-xpath* is NULL, then an error is raised.
- If *target-data* or *parent-xpath* is NULL, then NULL is returned.
- If *child-data* is NULL, then no insertion is done, and *target-data* is returned unchanged.

Figure C–4 shows the syntax.

Figure C–4 INSERTCHILDXMLAFTER Syntax



INSERTXMLBEFORE Deprecated Oracle SQL Function

Deprecated Oracle SQL function insertXMLbefore inserts one or more nodes of any kind immediately before a target node that is not an attribute node. The XML document that is the target of the insertion can be schema-based or non-schema-based.

A *copy* of the input XMLType instance is modified and returned. The original data is unaffected. You can then use the returned data with SQL operation UPDATE to modify database data.

Function insertXMLbefore has the following parameters (in order):

- ***target-data*** (XMLType) – The XML data that is the target of the insertion.
- ***successor-xpath*** (VARCHAR2) – An XPath 1.0 expression that locates zero or more nodes in *target-data* of any kind *except* attribute nodes. *XML-data* is inserted

immediately before *each* of these nodes. Thus, the nodes in *XML-data* become preceding siblings of each of the *successor-xpath* nodes.

If *successor-xpath* matches an empty sequence of nodes, then no insertion is done, and *target-data* is returned unchanged (no error is raised). If *successor-xpath* does not match a sequence of nodes that are not attribute nodes, then an error is raised.

- ***XML-data*** (XMLType) – The XML data to be inserted: one or more nodes of *any kind*. The order of the nodes is preserved after the insertion.
- ***namespace*** (*optional*, VARCHAR2) – The namespace for parameter *successor-xpath*.

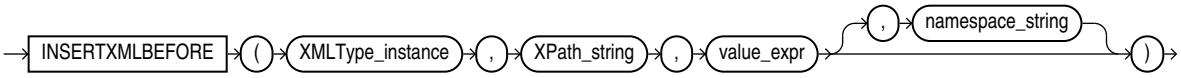
The *XML-data* nodes are inserted immediately before *each* of the non-attribute nodes located at *successor-xpath*.

Function insertXMLbefore has the following behavior for NULL arguments:

- If *target-data* or *parent-xpath* is NULL, then NULL is returned.
- Otherwise, if *child-data* is NULL, then no insertion is done, and *target-data* is returned unchanged.

Figure C–5 shows the syntax.

Figure C–5 INSERTXMLBEFORE Syntax



Example C–11 uses deprecated Oracle SQL function insertXMLbefore to insert a LineItem element before the first LineItem element.

Example C–11 Insertion Before an Element Using INSERTXMLBEFORE (Deprecated)

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[1]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[1]'PASSINGPO.OBJECT_
--------------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>Salesman</Description>
  <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
</LineItem>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      insertXMLbefore(OBJECT_VALUE,
                      '/PurchaseOrder/LineItems/LineItem[1]',
                      XMLType('<LineItem ItemNumber="314">
                                 <Description>Brazil</Description>
                                 <Part Id="314159265359"
                                       UnitPrice="69.95"
                                       Quantity="2"/>
                               </LineItem>'))
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING OBJECT_VALUE AS "p");
```

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[position() <= 2]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[POSITION()<=2]'PASSINGPO.OBJECT_
--------------------------------------------------------------------------------
<LineItem ItemNumber="314">
  <Description>Brazil</Description>
  <Part Id="314159265359" UnitPrice="69.95" Quantity="2"/>
</LineItem>
<LineItem ItemNumber="1">
  <Description>Salesman</Description>
  <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
</LineItem>
```

> **Note:** Queries that use Oracle SQL function `insertXMLbefore` are *not* optimized. For this reason, Oracle recommends that you use function `insertChildXML`, `insertChildXMLbefore`, or `insertChildXMLafter` instead. See "Performance Tuning for XQuery" on page 5-39.

INSERTXMLAFTER Deprecated Oracle SQL Function

Deprecated Oracle SQL function `insertXMLafter` inserts one or more nodes of any kind immediately after a target node that is not an attribute node. The XML document that is the target of the insertion can be schema-based or non-schema-based. It is thus similar to `insertXMLbefore`, but it inserts after, not before, the target node.

A *copy* of the input `XMLType` instance is modified and returned. The original data is unaffected. You can then use the returned data with SQL operation `UPDATE` to modify database data.

Function `insertXMLafter` has the following parameters (in order):

- ***target-data*** (`XMLType`) – The XML data that is the target of the insertion.
- ***successor-xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates zero or more nodes in *`target-data`* of any kind *except* attribute nodes. *`XML-data`* is inserted immediately after *each* of these nodes. Thus, the nodes in *`XML-data`* become succeeding siblings of each of the *`successor-xpath`* nodes.

  If *`successor-xpath`* matches an empty sequence of nodes, then no insertion is done, and *`target-data`* is returned unchanged (no error is raised). If *`successor-xpath`* does not match a sequence of nodes that are not attribute nodes, then an error is raised.
- ***XML-data*** (`XMLType`) – The XML data to be inserted: one or more nodes of *any kind*. The order of the nodes is preserved after the insertion.
- ***namespace*** (*optional*, `VARCHAR2`) – The namespace for parameter *`successor-xpath`*.

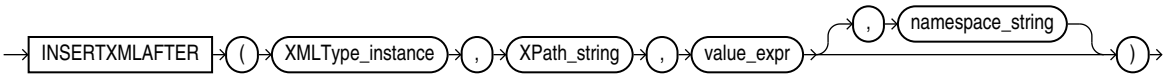
The *`XML-data`* nodes are inserted immediately after *each* of the non-attribute nodes located at *`successor-xpath`*.

Function `insertXMLafter` has the following behavior for `NULL` arguments:

- If *`target-data`* or *`parent-xpath`* is `NULL`, then `NULL` is returned.
- Otherwise, if *`child-data`* is `NULL`, then no insertion is done, and *`target-data`* is returned unchanged.

Figure C–6 shows the syntax.

Figure C–6 INSERTXMLAFTER Syntax



Note: Queries that use Oracle SQL function `insertXMLafter` are *not* optimized. For this reason, Oracle recommends that you use function `insertChildXML`, `insertChildXMLbefore`, or `insertChildXMLafter` instead. See "Performance Tuning for XQuery" on page 5-39.

APPENDCHILDXML Deprecated Oracle SQL Function

Deprecated Oracle SQL function `appendChildXML` inserts one or more nodes of any kind as the last children of a given element node. The XML document that is the target of the insertion can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned. The original data is unaffected. You can then use the returned data with SQL operation `UPDATE` to modify database data.

Function `appendChildXML` has the following parameters (in order):

- ***target-data*** (`XMLType`)– The XML data containing the target parent element.
- ***parent-xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates zero or more *element* nodes in *`target-data`* that are the targets of the insertion operation. The *`child-data`* is inserted as the last child or children of *each* of these parent elements.

  If *`parent-xpath`* matches an empty sequence of element nodes, then no insertion is done, and *`target-data`* is returned unchanged (no error is raised). If *`parent-xpath`* does not match a sequence of element nodes (in particular, if *`parent-xpath`* matches one or more *attribute* or *text* nodes), then an error is raised.
- ***child-data*** (`XMLType`) – Child data to be inserted: one or more nodes of *any kind*. The order of the nodes is preserved after the insertion.
- ***namespace*** (*optional*, `VARCHAR2`) – The namespace for parameter *`parent-xpath`*.

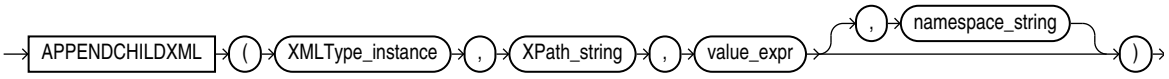
XML data *`child-data`* is inserted as the last child or children of *each* of the element nodes indicated by *`parent-xpath`*.

Function `appendChildXML` has the following behavior for `NULL` arguments:

- If *`target-data`* or *`parent-xpath`* is `NULL`, then `NULL` is returned.
- Otherwise, if *`child-data`* is `NULL`, then no insertion is done, and *`target-data`* is returned unchanged.

Figure C–7 shows the syntax.

Figure C–7 APPENDCHILDXML Syntax



Example C–12 uses deprecated Oracle SQL function `appendChildXML` to insert a `Date` element as the last child of an `Action` element.

Example C–12 Insertion as the Last Child Using APPENDCHILDXML (Deprecated)

```
SELECT XMLQuery('$p/PurchaseOrder/Actions/Action[1]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/ACTIONS/ACTION[1]'PASSINGPO.OBJECT_VALUE
--------------------------------------------------------------------
<Action>
  <User>KPARTNER</User>
</Action>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      appendChildXML(OBJECT_VALUE,
                     'PurchaseOrder/Actions/Action[1]',
                     XMLType('<Date>2002-11-04</Date>'))
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLQuery('$p/PurchaseOrder/Actions/Action[1]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/ACTIONS/ACTION[1]'PASSINGPO.OBJECT_VALUE
--------------------------------------------------------------------
<Action>
  <User>KPARTNER</User>
  <Date>2002-11-04</Date>
</Action>
```

> **Note:** Queries that use Oracle SQL function `appendChildXML` are *not* optimized. For this reason, Oracle recommends that you use function `insertChildXML`, `insertChildXMLbefore`, or `insertChildXMLafter` instead. See "Performance Tuning for XQuery" on page 5-39.

DELETEXML Deprecated Oracle SQL Function

Deprecated Oracle SQL function `deleteXML` deletes XML nodes of any kind. The XML document that is the target of the deletion can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned. The original data is unaffected. You can then use the returned data with SQL operation `UPDATE` to modify database data.

Function `deleteXML` has the following parameters (in order):

- ***target-data*** (`XMLType`) – The XML data containing the target nodes (to be deleted).
- ***xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates zero or more nodes in *`target-data`* that are the targets of the deletion operation. *Each* of these nodes is deleted.

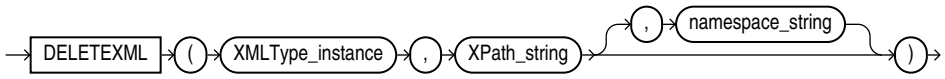
If *xpath* matches an empty sequence of nodes, then no deletion is done, and *target-data* is returned unchanged (no error is raised). If *xpath* matches the top-level element node, then an error is raised.

- ***namespace*** (*optional*, VARCHAR2) – The namespace for parameter *xpath*.

The XML nodes located at *xpath* are deleted from *target-data*. Function deleteXML returns NULL if *target-data* or *xpath* is NULL.

Figure C–8 shows the syntax.

Figure C–8 DELETEXML Syntax



Example C–13 uses deprecated Oracle SQL function deleteXML to delete the LineItem element whose ItemNumber attribute has value 222.

Example C–13 Deletion of an Element Using DELETEXML (Deprecated)

```
SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[@ItemNumber=222]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER=222]'PASSINGPO
--------------------------------------------------------------------------------
<LineItem ItemNumber="222">
  <Description>The Harder They Come</Description>
  <Part Id="953562951413" UnitPrice="22.95" Quantity="1"/>
</LineItem>

UPDATE purchaseorder
  SET OBJECT_VALUE =
      deleteXML(OBJECT_VALUE,
                '/PurchaseOrder/LineItems/LineItem[@ItemNumber="222"]')
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING OBJECT_VALUE AS "p");

SELECT XMLQuery('$p/PurchaseOrder/LineItems/LineItem[@ItemNumber=222]'
                PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
  FROM purchaseorder po
  WHERE XMLExists('$p/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]'
                  PASSING po.OBJECT_VALUE AS "p");

XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER=222]'PASSINGPO
--------------------------------------------------------------------------------

1 row selected.
```

D

Deprecated Constructs for XML Translation

This appendix describes Oracle constructs that support XML translation, which are *deprecated* starting with Oracle Database 12*c* Release 1 (12.1.0.1).

This appendix contains these topics:

- XML Translations (Deprecated)
- PL/SQL Package DBMS_XMLTRANSLATIONS (Deprecated)

XML Translations (Deprecated)

You can store XML documents in Oracle XML DB Repository as `XMLType` instances. (You can use either object-relational or binary XML storage.) These documents sometimes contain strings that must be translated into various (natural) languages.

To use the deprecated Oracle XML translation support, you store both the original strings and their translations in the repository. You can then retrieve and operate on these strings, depending on your language settings.

Note: XML schemas stored object-relationally are not translatable.

Changes to an XML Schema and XML Instance Documents for Translation (Deprecated)

This section describes the changes that you must make to an XML schema and an associated XML instance document to make the document translatable.

Indication of Translatable Elements in an XML Schema (Deprecated)

Attribute `xdb:translate` must be specified in the XML schema for each element that is to be translated. The following restrictions apply to attribute `xdb:translate`.

1. Attribute `xdb:translate` can be specified only on `complexType` elements that have `simpleContent`. Here, `simpleContent` must be an extension or a restriction of type `string`. However, if a `complexType` element has the `xdb:translate` flag set, then none of its descendants can have this flag set.
2. Attribute `xdb:translate` can be set only on a single-valued element, which has exactly one translation. For such an element, the value of `xdb:maxOccurs` must be `0` or `1`. If you want to set this attribute on a multiple-valued element, the element must have an `ID` attribute, which uniquely identifies the element.

During XML schema registration, PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema` checks whether the XML schema satisfies these restrictions.

Indication of Translation Language Attributes in an XML Instance Document

The following translation language attributes are supported:

- `xml:lang`: For an instance document associated with an XML schema that supports translations, you must specify the translation language. You can do this by annotating each translation with attribute `xml:lang`. The allowed values of the `xml:lang` attribute are the language identifiers identified by IETF RFC 3066.
- `xdb:srclang`: For multiple-valued elements, that is, elements that can have multiple translations, only one translation can be used as the source language translation. That translation is specified by attribute `xdb:srclang`. This is the default translation, which is returned when the session language is not specified.

Making XML Documents Translatable (Deprecated)

This section uses the translation-specifying XML schema attributes to make elements in a sample document translatable. Example D–1 shows an XML schema that defines documents that contain a title string that needs to be translatable.

Example D–1 XML Schema Defining Documents with a Title To Be Translated

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdbsc="http://xmlns.oracle.com/xdb/security.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb.xsd"
        targetNamespace="http://xmlns.oracle.com/xdb/security.xsd"
        elementFormDefault="qualified" version="1.0">
  <annotation>
    <documentation>
This XML schema describes the structure of Security Class documents.
    </documentation>
  </annotation>
  <element name="securityClass" xdb:defaultTable="">
    <complexType>
      <sequence>
        <element name="name" type="string"/>
        <element name="title" minOccurs="0" maxOccurs="unbounded"/>
        <element name="inherits-from" type="QName" minOccurs="0" maxOccurs="unbounded"/>
        <element name="privlist" minOccurs="0" maxOccurs="unbounded">
          <complexType>
            <choice minOccurs="0" maxOccurs="unbounded">
              <element ref="xdbsc:privilege"/>
                <element ref="xdbsc:aggregatePrivilege"/>
            </choice>
          </complexType>
        </element>
        <!-- this "any" contains all application specific information
             for a security class in general e.g. reason for creation  -->
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <attribute name="targetNamespace" type="anyURI" use="required"/>
      <!-- all privileges in this security class are under this target namespace -->
    </complexType>
  </element>
  <element name="aggregatePrivilege">
    <complexType>
      <sequence>
        <element name="title" minOccurs="0" maxOccurs="unbounded"/>
        <sequence maxOccurs="unbounded">
          <element name="privilegeRef">
            <complexType>
```

```
            <attribute name="name" type="QName" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           an aggregate privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
 </element>
 <element name="privilege">
  <complexType>
    <sequence minOccurs="0">
      <element name="title" minOccurs="0" maxOccurs="unbounded"/>
      <sequence minOccurs="0" maxOccurs="unbounded">
        <element name="columnRef">
          <complexType>
            <attribute name="schema" type="string" use="required"/>
            <attribute name="table" type="string" use="required"/>
            <attribute name="column" type="string" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           for a privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
 </element>
</schema>
```

Example D–2 shows a document that is associated with the XML schema of Example D–1.

Example D–2 Untranslated Instance Document

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title>
Security Class Example
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
  <privlist>
  <privilege name="privilege1"/>
  <aggregatePrivilege name="iStorePOApprover">
    <title>
iStore Purchase Order Approver
    </title>
    <privilegeRef name="is:privilege1"/>
    <privilegeRef name="oa:submitPO"/>
    <privilegeRef name="oa:privilege3"/>
```

```
  </aggregatePrivilege>
  <privilege name="privilege2">
    <title>
secondary privilege
    </title>
    <columnRef schema="APPS" table="PurchaseOrder" column="POId"/>
    <columnRef schema="APPS" table="PurchaseOrder" column="Amount"/>
  </privilege>
  </privlist>
</securityClass>
```

To make the top-level title translatable, set `xdb:translate` to `true`. This is a single-valued element (`xdb:maxOccurs` is `1`). Example D–3 shows the new XML schema, where attribute `xdb:translate` is `true`.

Example D–3 XML Schema with Attribute xdb:translate for a Single-Valued Element

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdbsc="http://xmlns.oracle.com/xdb/security.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb.xsd"
        targetNamespace="http://xmlns.oracle.com/xdb/security.xsd"
        elementFormDefault="qualified" version="1.0">
<xs:import namespace="http://www.w3.org/XML/1998/namespace"
        schemaLocation="http://www.w3.org/2001/xml.xsd"/>
<xs:import namespace-"http://xmlns.oracle.com/xdb"
        schemaLocation="http://xmlns.oracle.com/xdb/xmltr.xsd"/>
  <annotation>
    <documentation>
This XML schema describes the structure of Security Class documents.
    </documentation>
  </annotation>
  <element name="securityClass" xdb:defaultTable="">
    <complexType>
      <sequence>
        <element name="name" type="string"/>
        <element ref="titleref" minOccurs="0" maxOccurs="unbounded"
                 xdb:maxOccurs="1" xdb:translate="true"/>
        <element name="inherits-from" type="QName" minOccurs="0" maxOccurs="unbounded"/>
        <element name="privlist" minOccurs="0" maxOccurs="unbounded" xdb:maxOccurs="1">
          <complexType>
            <choice minOccurs="0" maxOccurs="unbounded">
              <element ref="xdbsc:privilege"/>
              <element ref="xdbsc:aggregatePrivilege"/>
            </choice>
          </complexType>
        </element>
        <!-- this "any" contains all application specific information
             for a security class in general e.g. reason for creation  -->
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <attribute name="targetNamespace" type="anyURI" use="required"/>
      <!-- all privileges in this security class are under this target namespace -->
    </complexType>
  </element>
  <element name="aggregatePrivilege">
    <complexType>
      <sequence>
        <element name="title" minOccurs="0" maxOccurs="unbounded"/>
        <sequence maxOccurs="unbounded">
          <element name="privilegeRef">
```

```
          <complexType>
            <attribute name="name" type="QName" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           an aggregate privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
</element>
<element name="privilege">
  <complexType>
    <sequence minOccurs="0">
      <element name="title" minOccurs="0" maxOccurs="unbounded"/>
      <sequence minOccurs="0" maxOccurs="unbounded">
        <element name="columnRef">
          <complexType>
            <attribute name="schema" type="string" use="required"/>
            <attribute name="table" type="string" use="required"/>
            <attribute name="column" type="string" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           for a privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
</element>
<element name="titleref">
  <complexType>
    <simpleContent>
      <extension base="xs:string">
        <attribute ref="xml:lang"/>
        <attribute ref="xdb:srclang"/>
      </extension>
    </simpleContent>
  </complexType>
</element>
</schema>
```

Example D–4 shows an instance document after translation of the title text.

Example D–4 Translated Document

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps">
  <name>
securityClassExample
  </name>
  <title xml:lang="en" xdb:srclang="true">
Security Class Example
  </title>
  <title xml:lang="es">
```

```
Security Class Example - Spanish
  </title>
  <title xml:lang="fr">
Security Class Example - French
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
  <privlist>
    <privilege name="privilege1"/>
    <aggregatePrivilege name="iStorePOApprover">
      <title>
iStore Purchase Order Approver
      </title>
      <privilegeRef name="is:privilege1"/>
      <privilegeRef name="oa:submitPO"/>
      <privilegeRef name="oa:privilege3"/>
    </aggregatePrivilege>
    <privilege name="privilege2">
      <title>
secondary privilege
      </title>
      <columnRef schema="APPS" table="PurchaseOrder" column="POId"/>
      <columnRef schema="APPS" table="PurchaseOrder" column="Amount"/>
    </privilege>
  </privlist>
</securityClass>
```

To make the title translatable in the case of a multi-valued element, you would set `xdb:maxOccurs` to `unbounded`. However, `xdb:translate` cannot be set to `true` for a multiple-valued element, unless there is an identifier attribute that uniquely identifies each element. Example D–5 shows an XML schema that uses an identifier attribute `id` for the `title` element.

Example D–5 XML Schema with Attribute xdb:translate for a Multi-Valued Element

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdbsc="http://xmlns.oracle.com/xdb/security.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb.xsd"
        targetNamespace="http://xmlns.oracle.com/xdb/security.xsd"
        elementFormDefault="qualified" version="1.0">
<xs:import namespace="http://www.w3.org/XML/1998/namespace"
        schemaLocation="http://www.w3.org/2001/xml.xsd"/>
<xs:import namespace-"http://xmlns.oracle.com/xdb"
        schemaLocation="http://xmlns.oracle.com/xdb/xmltr.xsd"/>
  <annotation>
    <documentation>
This XML schema describes the structure of Security Class documents.
    </documentation>
  </annotation>
  <element name="securityClass" xdb:defaultTable="">
    <complexType>
      <sequence>
        <element name="name" type="string"/>
        <element name="title" minOccurs="0" maxOccurs="unbounded" xdb:maxOccurs="1"/>
        <element name="inherits-from" type="QName" minOccurs="0" maxOccurs="unbounded"/>
        <element name="privlist" minOccurs="0" maxOccurs="unbounded" xdb:maxOccurs="1">
          <complexType>
            <choice minOccurs="0" maxOccurs="unbounded">
              <element ref="xdbsc:privilege"/>
              <element ref="xdbsc:aggregatePrivilege"/>
            </choice>
```

```
        </complexType>
      </element>
      <!-- this "any" contains all application specific information
           for a security class in general e.g. reason for creation  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="targetNamespace" type="anyURI" use="required"/>
    <!-- all privileges in this security class are under this target namespace -->
  </complexType>
</element>
<element name="aggregatePrivilege">
  <complexType>
    <sequence>
      <element name="titleref" minOccurs="0" maxOccurs="unbounded"
               xdb:maxOccurs="unbounded" xdb:translate="true"/>
      <sequence maxOccurs="unbounded">
        <element name="privilegeRef">
          <complexType>
            <attribute name="name" type="QName" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           an aggregate privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
</element>
<element name="privilege">
  <complexType>
    <sequence minOccurs="0">
      <element name="titleref" minOccurs="0" maxOccurs="unbounded"
               xdb:maxOccurs="unbounded" xdb:translate="true"/>
      <sequence minOccurs="0" maxOccurs="unbounded">
        <element name="columnRef">
          <complexType>
            <attribute name="schema" type="string" use="required"/>
            <attribute name="table" type="string" use="required"/>
            <attribute name="column" type="string" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           for a privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
</element>
<element name="titleref">
  <complexType>
    <simpleContent>
      <extension base="xs:string">
        <attribute ref="xml:lang"/>
        <attribute ref="xdb:srclang"/>
        <attribute name="id" type="integer"/>
      </extension>
```

```
      </simpleContent>
    </complexType>
  </element>
</schema>
```

Example D–6 shows a document associated with the XML schema in Example D–5.

Example D–6 Translated Document for an XML Schema with Multiple-Valued Elements

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps">
  <name>
securityClassExample
  </name>
  <title>
Security Class Example
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
  <privlist>
    <privilege name="privilege1"/>
    <aggregatePrivilege name="iStorePOApprover">
      <title>
iStore Purchase Order Approver
      </title>
      <privilegeRef name="is:privilege1"/>
      <privilegeRef name="oa:submitPO"/>
      <privilegeRef name="oa:privilege3"/>
    </aggregatePrivilege>
    <privilege name="privilege2">
      <title id="2" xml:lang="en" xdb:srclang="true">
secondary privilege - english
      </title>
      <title id="1" xml:lang="fr">
primary privilege - french
      </title>
      <title id="1" xml:lang="en" xdb:srclang="true">
primary privilege - english
      </title>
      <columnRef schema="APPS" table="PurchaseOrder" column="POId"/>
      <columnRef schema="APPS" table="PurchaseOrder" column="Amount"/>
    </privilege>
  </privlist>
</securityClass>
```

Operations on Translated Documents (Deprecated)

You can perform the following operations on translated documents:

- Insert: You can insert a document into Oracle XML DB, if it conforms to an XML schema that supports translations. For the document that contains translations, you can either provide the language information or use the session language translation.
  - When the document does not contain the language information and the `xml:lang` attribute is not set, the session language is used for translation. Example D–7 describes a document with a session language of Japanese. Attribute `xml:lang` is set to `session language`, and attribute `xdb:srclang` is set to `true`.

Example D–7 Inserting a Document with No Language Information

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title>
Security Class Example
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

Example D–8 shows the document after it is inserted into Oracle XML DB Repository.

Example D–8 Document After Insertion into the Repository

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title xml:lang="jp" xdb:srclang="true">
Security Class Example
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

– When you provide the language information, you set attribute `xml:lang` by either explicitly marking a translation as `xdb:srclang=true` or using the session language translation in attribute `xdb:srclang`. If you do neither, then an arbitrary translation is picked, for which `xdb:srclang` is set to `true`.

  Example D–9 describes a document with a session language of Japanese.

Example D–9 Inserting a Document with Language Information

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title xml:lang="en">
Security Class Example
  </title>
  <title xml:lang="fr">
Security Class Example - FR
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

Example D–10 shows the document after it is inserted into Oracle XML DB Repository.

Example D–10 Document After Insertion

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title xml:lang="en" xdb:srclang="true">
Security Class Example
  </title>
  <title xml:lang="fr">
Security Class Example - FR
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

- Query: If you query nodes that involve translated elements, the query displays the translation's default behavior. In order to specify that the translation's default behavior should be applied to the query result, you need to use the Oracle XPath function `ora:translate`. This is the syntax of the function:

  ```
  Nodeset ora:translate(Nodeset parent, String childname, String childnsp)
  ```

  Parameter *parent* is the parent node under which you want to search for the translated nodes; *childname* is the name of the child node; and *childnsp* is the namespace URL of the child node.

  Function `ora:translate` returns a positive integer when the name of the parent node matches the name of the specified child node, and the `xml:lang` value is same as the session language or the language for which `xdb:srclang` is `true`.

  When SQL functions such as `XMLQuery` are applied to translated documents, they return the session language translation, if present, or the source language translation, otherwise. For example, this query returns the session language translation:

  ```
  SELECT XMLQuery('$x/ora:translate(securityClass, "title")'
                  PASSING x.OBJECT_VALUE AS "x" RETURNING CONTENT)
    FROM some_table x;
  ```

  This is the output of that query:

  ```
  <title xml:lang="fr">
  Security Class Example - FR
  </title>
  ```

  To obtain the result in a particular language, specify it in the XPath expression.

  ```
  SELECT XMLQuery('$x/securityClass/title[@xml:lang="en"]'
                  PASSING x.OBJECT_VALUE AS "x" RETURNING CONTENT)
    FROM some_table x;
  ```

  This is the output of that query:

  ```
  <title xml:lang="en" xdb:srclang="true">
  Security Class Example
  </title>
  ```

Because you can store translated documents only as text (CLOB) or binary XML, only functional evaluation and queries with a function-based index, an XMLIndex index, or a CONTEXT index are possible. For XMLIndex index and CONTEXT index queries, if the document has a session language translation, then that is returned, otherwise the source language translation is returned. However, for queries with a function-based index, you need to create an index with an explicit xml:lang predicate for every language for which you want to use the index.

When you retrieve the complete document using SQL function XMLSerialize and PL/SQL constructor XDBURIType, only the translations that match the session language translations are returned. For protocols, you can set your language preferences, and the document is returned in that language only.

The following PL/SQL procedures and functions support XML translations:

- DBMS_XMLTRANSLATIONS.translateXML: Translate a document to the specified language. If the specified language translation is present, it is returned, otherwise, the source language translation is returned.

  For example, if you write translateXML(doc, 'fr') to specify French as the translation language for the Example D–10, it returns the following code and ignores all other translations:

```
securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
              xmlns:is="xmlns.oracle.com/iStore"
              xmlns:oa="xmlns.oracle.com/OracleApps"
              targetNamespace="xmlns.oracle.com/example">
    <name>
        securityClassExample
    </name>
    <title xml:lang="fr">
        Security Class Example - FR
    </title>
    <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

  - DBMS_XMLTRANSLATIONS.enableTranslation, DBMS_XMLTRANSLATIONS.disableTranslation: Enable or disable translations at the session level. Queries work on the base document if the translation is disabled and on the translated document if it is enabled.
  - DBMS_XMLTRANSLATIONS.getBaseDocument: Returns the entire document, with all of the translations.

- Update: You can use Oracle SQL function XMLQuery together with XQuery Update to update the translated nodes. However, an error is raised if you try to update a translated node without specifying the translation language. The following PL/SQL procedures support update operations on translated documents:
  - DBMS_XMLTRANSLATIONS.updateTranslation: This function updates the translation at a specified xpath in a particular language. If the translation in a particular language is not present, then it is inserted.
  - DBMS_XMLTRANSLATIONS.setSourceLang: This procedure sets the source language at a specified xpath to the specified language.

PL/SQL Package DBMS_XMLTRANSLATIONS (Deprecated)

When you store security objects in the Oracle XML DB Repository, you store them as XMLType instances. The security objects also contain some strings that must be

translated, so that you can search for or display them in various languages. The translations for these strings are also stored in the Oracle XML DB Repository, along with the original strings, because they must be associated with the original document. You can retrieve and operate on these strings, depending on your language settings.

Oracle XML DB provides translation support through the `DBMS_XMLTRANSLATIONS` package, which provides an interface to perform translations so that strings can be searched or displayed in various languages.

> **See Also:** Chapter 17, "XML Schema Storage and Query: Basic" for an overview of XML translations

DBMS_XMLTRANSLATIONS Methods (Deprecated)

PL/SQL package `DBMS_XMLTRANSLATIONS` provides the following methods:

- `updateTranslation()`: Updates the translation in a particular language at the specified `XPATH`. If the translation in that language is not present, then it is inserted.
- `setSourceLang()`: Sets the source language to a particular language at the specified `XPATH`.
- `translateXML()`: Returns the document in the specified language.
- `getBaseDocument()`: Returns the base document with all the translations.
- `extractXLiff()`: Extracts the translations in `XLIFF` format from either an `XMLTYPE` instance or a resource in Oracle XML DB Repository.
- `mergeXLiff()`: Merges the translations in `XLIFF` format into either an `XMLTYPE` or a resource in Oracle XML DB Repository.
- `disableTranslation()`: Disables translations in the current session so that query or retrieval takes place on the base document, ignoring session language values.
- `enableTranslation()`: Enables translations in the current session.

> **See Also:** *Oracle Database PL/SQL Packages and Type References* for a description of the individual `DBMS_XMLTRANSLATIONS` methods.

E

Full-Text Search over XML Data Without XQuery

This appendix describes Oracle-specific full-text search over XML data. It explains how to use Oracle SQL function `contains` and Oracle XPath function `ora:contains`.

You can use these Oracle-specific functions to perform full-text search over XML data, but if your `XMLType` data is stored as binary XML then Oracle recommends that you instead use the full-text capabilities of XQuery. The XQuery and XPath Full Text standard is supported by Oracle XML DB, starting with Oracle Database 12c Release 1 (12.1.0.1).

See Also:

- Chapter 4, "XQuery and Oracle XML DB"
- "Indexing XML Data for Full-Text Queries" on page 6-48
- *Oracle Text Reference* and *Oracle Text Application Developer's Guide* for more information about Oracle Text

This chapter contains these topics:

Overview of Oracle-Specific Full-Text Search over XML Data

If your documents are XML, then you can use the XML structure of the document to restrict the full-text search. For example, you may want to find all purchase orders that contain the word "electric" using full-text search. If the purchase orders are in XML form, then you can restrict the search by finding all purchase orders that contain the word "electric" in a comment, or by finding all purchase orders that contain the word "electric" in a comment under line items.

If your XML documents are of type `XMLType`, then you can project the results of your query using the XML structure of the document. For example, after finding all

purchase orders that contain the word "electric" in a comment, you may want to return just the comments, or just the comments that contain the word "electric".

Comparison of Full-Text Search and Other Search Types

Full-text search differs from structured search or substring search in the following ways:

- A full-text search looks for whole *words* rather than substrings. A substring search for comments that contain the *string* "law" can return a comment that contains "my *law*n is going wild". A full-text search for the *word* "law" cannot.
- A full-text search supports some language-based and word-based searches that substring searches do not. You can use a language-based search, for example, to find all the comments that contain a word with the same linguistic stem as "mouse", and Oracle Text finds "mouse" and "mice". You can use a word-based search, for example, to find all the comments that contain the word "lawn" within 5 words of "wild".
- A full-text search generally involves some notion of relevance. When you do a full-text search for all the comments that contain the word "lawn", for example, some results are more relevant than others. Relevance is often related to the number of times the search word (or similar words) occur in the document.

Search of XML DataBarri8ora

XML search is different from unstructured document search. In unstructured document search you generally search across a set of documents to return the documents that satisfy your text predicate. In XML search you often want to use the structure of the XML document to restrict the search. And you often want to return just the part of the document that satisfies the search.

Searching Documents Using Full-Text Search and XML Structure

There are two ways to do a search that includes full-text search and XML structure:

- Include the structure inside the full-text predicate, using Oracle SQL function `contains`:

  ```
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items/item/comment)') > 0
  ```

  Function `contains` is an extension to SQL, and can be used in any query. It requires a `CONTEXT` full-text index.

- Include the full-text predicate inside the structure, using XPath function `ora:contains`:

  ```
  '/purchaseOrder/items/item/comment[ora:contains(text(), "electric")>0]'
  ```

  XPath function `ora:contains` is an extension to XPath, and can be used in a call to SQL/XML function `XMLQuery`, `XMLTable`, or `XMLExists`.

About the Full-Text Search Examples

This section describes details about the examples included in this chapter.

Roles and Privileges

To run the examples, you need database roles `CTXAPP`, `CONNECT`, and `RESOURCE`. You must also have `EXECUTE` privilege on the `CTXSYS` package `CTX_DDL`.

Schema and Data for Full-Text Search Examples

Examples in this chapter are based on "The Purchase Order Schema", W3C XML Schema Part 0: Primer.

See Also: `http://www.w3.org/TR/xmlschema-0/#POSchema`

The data in the examples is from the document "Purchase-Order XML Document, po001.xml" on page E-27.

The tables used in the examples of this chapter are defined in section "CREATE TABLE Statements""CREATE TABLE Statements". Some of the performance examples are, however, based on a larger table (`purchase_orders_xmltype_big`), which is included in the downloadable version only. See `http://www.w3.org/TR/xmlschema-0/#po.xml`.

Some of the examples here use data type `VARCHAR2`. Others use type `XMLType`. All examples that use `VARCHAR2` also work with `XMLType`.

Overview of SQL Function CONTAINS and XPath Function ora:contains

This section contains these topics:

- Overview of SQL Function CONTAINS
- Overview of XPath Function ora:contains
- Comparison of SQL Function CONTAINS and XPath Function ora:contains

Overview of SQL Function CONTAINS

Oracle SQL function `contains` returns a positive number for rows where `[schema.]column` matches `text_query`. Otherwise, it returns zero. It requires an index of type `CONTEXT`. If there is no `CONTEXT` index on the column being searched, then `contains` raises an error.

CONTAINS Syntax

```
contains([schema.]column, text_query VARCHAR2 [,label NUMBER])
RETURN NUMBER
```

Example E–1 shows a typical query that uses Oracle SQL function `contains`. It returns the `id` for each row in table `purchase_orders` where the `doc` column contains the word "lawn" and `id` is less than 25.

Example E–1 Simple Query Using Oracle SQL Function CONTAINS

```
SELECT id FROM purchase_orders WHERE contains(doc, 'lawn') > 0 AND id < 25;
```

Suppose `doc` is a column that contains a set of XML documents. You can do full-text search over `doc`, using its XML structure to restrict the query. The query in Example E–2 returns `id` values for table `purchaseorders` where column `doc` contains the word "lawn" in the text() node of XML element `comment`.

Example E–2 Restricting a Query Using CONTAINS and WITHIN

```
SELECT id FROM purchase_orders WHERE contains(doc, 'lawn WITHIN comment') > 0;
```

More complex XML structure restrictions can be applied using the `INPATH` operator and an XPath expression. The query in Example E–3 finds purchase orders that contain the word "electric" in the text() node of a `comment` element that is targeted by XPath expression `/purchaseOrder/items/item/comment`.

Example E–3 Restricting a Query Using CONTAINS and INPATH

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items/item/comment)') > 0;
```

Overview of XPath Function ora:contains

XPath function `ora:contains` can be used in an XPath expression inside an XQuery expression or in a call to SQL/XML function `XMLQuery`, `XMLTable`, or `XMLExists`. It is used to restrict a structural search with a full-text predicate. It extends XPath through a standard mechanism: it is a user-defined function in the Oracle XML DB namespace, `ora`. It requires no index, but you can use an index with it to improve performance.

ora:contains Syntax

```
ora:contains(input_text NODE*, text_query STRING
             [,policy_name STRING]
             [,policy_owner STRING])
```

Function `ora:contains` returns a positive integer when the *`input_text`* matches *`text_query`* (the higher the number, the more relevant the match), and zero otherwise. When used in an XQuery expression, the XQuery return type is `xs:integer()`. When used in an XPath expression outside of an XQuery expression, the XPath return type is `number`.

Argument *`input_text`* must evaluate to a single text node or an attribute. The syntax and semantics of *`text_query`* in `ora:contains` are the same as *`text_query`* in `contains`, with the following restrictions:

- Argument *`text_query`* cannot include any structure operators (`WITHIN`, `INPATH`, or `HASPATH`).
- If the `weight` score-weighting operator is used, the weights are *ignored*.

Example E–4 shows a call to `ora:contains` in the XPath parameter to `XMLExists`. Notice the namespace declaration that declares prefix `ora` as representing the Oracle XML DB namespace.

Example E–4 ora:contains with an Arbitrarily Complex Text Query

```
SELECT id
  FROM purchase_orders_xmltype
  WHERE
    XMLExists(
      'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
       $d/purchaseOrder/comment
         [ora:contains(text(), "($lawns AND wild) OR flamingo") > 0]'
      PASSING doc AS "d");
```

> **See Also:** "ora:contains XQuery Function" on page E-17 for more on the `ora:contains` XPath function

Comparison of SQL Function CONTAINS and XPath Function ora:contains

Both Oracle SQL function `contains` and Oracle XPath function `ora:contains` let you combine searching on XML structure with full-text searching. These are the main differences between them:

Oracle SQL function `contains`:

- Needs a `CONTEXT` index to run. If there is no index, then an error is raised.
- Does an indexed search and is generally very fast.
- Returns a score (through Oracle SQL function `score`).
- Restricts a search based on documents (rows in a table) rather than nodes.
- *Cannot* be used for XML structure-based projection (extracting parts of an XML document).

Oracle XPath function `ora:contains`:

- Does not need an index to run, but you can use an index to improve performance.
- Might do an unindexed search, so it might be resource-intensive.
- Separates application logic from storing and indexing considerations.
- Does *not* return a score.
- Can be used for XML structure-based projection (extracting parts of an XML document).

Use Oracle SQL function `contains` when you want a fast, index-based, full-text search over XML documents, possibly with simple XML structure constraints. Use Oracle XPath function `ora:contains` when you need the flexibility of full-text search combined with XPath navigation (possibly without an index) or when you need to do projection, and you do not need a score.

SQL Function CONTAINS

This section contains these topics:

Full-Text Search Using SQL Function CONTAINS

The second argument to Oracle SQL function `contains`, `text_query`, is a string that specifies the full-text search. `text_query` has its own language, based on the SQL/MM Full-Text standard.

See Also:

- ISO/IEC 13249-2:2000, Information technology - Database languages - SQL Multimedia and Application Packages - Part 2: Full-Text, International Organization For Standardization, 2000
- *Oracle Text Reference* for more information about the operators in the `text_query` language

The examples in the rest of this section show some of the power of full-text search. They use only a few of the available operators. The example queries search over a `VARCHAR2` column (`PURCHASE_ORDERS.doc`) with a text index (index type `CTXSYS.CONTEXT`).

Full-Text Boolean Operators AND, OR, and NOT

The `text_query` language supports arbitrary combinations of `AND`, `OR`, and `NOT`. Precedence can be controlled using parentheses. The Boolean operators can be written in any of the following ways:

- `AND`, `OR`, `NOT`
- `and`, `or`, `not`
- `&`, `|`, `~`

Note that `NOT` is a *binary*, not a unary operator here. The expression `alpha NOT(beta)` is equivalent to `alpha AND` *unary-not*`(beta)`, where unary-not stands for unary negation.

See Also: *Oracle Text Reference* for complete information about the operators you can use in `contains` and `ora:contains`

Example E–5 CONTAINS Query with a Simple Boolean Operator

```
SELECT id FROM purchase_orders WHERE contains(doc, 'lawn AND wild') > 0;
```

Example E–6 CONTAINS Query with Complex Boolean

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '((lawn OR garden) AND (wild OR flooded)) NOT(flamingo)')
        > 0;
```

Full-Text Stemming: $

The `text_query` language supports stemmed search. Example E–7 returns all documents that contain some word with the same linguistic stem as "lawns", so it finds "lawn" or "lawns". The stem operator is written as a dollar sign (`$`).

Example E–7 CONTAINS Query with Stemming

```
SELECT id FROM purchase_orders WHERE contains(doc, '$(lawns)') > 0;
```

Combining Boolean and Stemming Operators

You can combine operators in the `text_query` language, as shown in Example E–8.

Example E–8 CONTAINS Query with Complex Query Expression

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '($lawns AND wild) OR flamingo') > 0;
```

See Also: *Oracle Text Reference* for a full list of `text_query` operators

SQL Function SCORE

Oracle SQL function `score` is related to Oracle SQL function `contains`. Function `score` can be used anywhere in a query. It is a measure of relevance, and it is especially useful when doing full-text searches across large document sets. Function `score` is typically returned as part of the query result, used in the `ORDER BY` clause, or both.

SCORE Syntax

```
score(label NUMBER) RETURN NUMBER
```

In Example E–9, `score(10)` returns the score for each row in the result set. Oracle SQL function `score` returns the relevance of a row in the result set with respect to a particular call to function `contains`. A call to `score` is linked to a call to `contains` by a `LABEL` (in this case the number 10).

Example E–9 Simple CONTAINS Query with SCORE

```
SELECT score(10), id FROM purchase_orders
  WHERE contains(doc, 'lawn', 10) > 0 AND score(10) > 2
  ORDER BY score(10) DESC;
```

Function `score` always returns `0` if, for the corresponding `contains` expression, argument `text_query` does not match `input_text`, according to the matching rules dictated by the text index. If the `contains` `text_query` matches the `input_text`, then `score` returns a number greater than `0` and less than or equal to `100`. This number indicates the relevance of the `text_query` to the `input_text`. A higher number means a better match.

If the `contains` `text_query` consists of only the `HASPATH` operator and a Text Path, the score is either `0` or `100`, because `HASPATH` tests for an exact match.

See Also: *Oracle Text Reference* for details on how the score is calculated

Scope of a CONTAINS Search

Oracle SQL function `contains` does a full-text search across the whole document, by default. In the example heres, a search for "lawn" with no structure restriction finds all purchase orders with the word "lawn" anywhere in them.

There are three ways to restrict `contains` queries using XML structure:

- `WITHIN`
- `INPATH`
- `HASPATH`

Note: For the purposes of this discussion, consider *section* to be the same as an *XML node*.

Using Structure Operator WITHIN

The WITHIN operator restricts a query to some section within an XML document. A search for purchase orders that contain the word "lawn" somewhere inside a comment section might use WITHIN. Section names are case-sensitive.

Example E–10 WITHIN

```
SELECT id FROM purchase_orders WHERE contains(DOC, 'lawn WITHIN comment') > 0;
```

Using Nested WITHIN You can restrict the query further by nesting WITHIN. Example E–11 finds all documents that contain the word "lawn" within a section "comment", where that occurrence of "lawn" is also within a section "item".

Example E–11 Nested WITHIN

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '(lawn WITHIN comment) WITHIN item') > 0;
```

Example E–11 returns no rows. Our sample purchase order does contain the word "lawn" within a comment. But the only comment within an item is "Confirm this is electric". So the nested WITHIN query returns no rows.

Using WITHIN Attributes You can also search within attributes. Example E–12 finds all purchase orders that contain the word 10 in the orderDate attribute of a purchaseOrder element.

Example E–12 WITHIN an Attribute

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '10 WITHIN purchaseOrder@orderDate') > 0;
```

By default, the minus sign ("-") is treated as a word separator: "1999-10-20" is treated as the three words "1999", "10" and "20". So this query returns one row.

Text in an attribute is not a part of the main searchable document. A search for 10 without qualifying the text_query with WITHIN purchaseOrder@orderDate returns no rows.

You cannot search attributes in a nested WITHIN.

Using WITHIN and AND Suppose you want to find purchase orders that contain two words within a comment section: "lawn" and "electric". There can be more than one comment section in a purchaseOrder. So there are two ways to write this query, with two distinct results.

If you want to find purchase orders that contain both words, where each word occurs in *some comment section*, you would write a query like Example E–13.

Example E–13 WITHIN and AND: Two Words in Some Comment Section

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '(lawn WITHIN comment) AND (electric WITHIN comment)') > 0;
```

If you run this query against the purchaseOrder data, then it returns 1 row. Note that the parentheses are not needed in this example, but they make the query more readable.

If you want to find purchase orders that contain both words, where both words occur *in the same comment*, you would write a query like Example E–14.

Example E–14 WITHIN and AND: Two Words in the Same Comment

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '(lawn AND electric) WITHIN comment') > 0;
```

The query in Example E–14 returns no rows. The query in Example E–15, which omits the parentheses around `lawn AND electric`, returns one row.

Example E–15 WITHIN and AND: No Parentheses

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'lawn AND electric WITHIN comment') > 0;
```

Operator `WITHIN` has a higher precedence than `AND`, so Example E–15 is parsed as Example E–16.

Example E–16 WITHIN and AND: Parentheses Illustrating Operator Precedence

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'lawn AND (electric WITHIN comment)') > 0;
```

Definition of Section The preceding examples have used the `WITHIN` operator to search within a section. A **section** can be a:

- **path** or **zone** section

  This is a concatenation, in document order, of all text nodes that are descendants of a node, with whitespace separating the text nodes. To convert from a node to a zone section, you must serialize the node and replace all tags with whitespace. path sections have the same scope and behavior as zone sections, except that path sections support queries with `INPATH` and `HASPATH` structure operators.

- **field** section

  This is the same as a zone section, except that repeating nodes in a document are concatenated into a single section, with whitespace as a separator.

- attribute section

- special section (sentence or paragraph)

  See Also: *Oracle Text Reference* for more information about special sections

Using Structure Operator INPATH

Operator `WITHIN` provides an easy and intuitive way to express simple structure restrictions in the `text_query`. For queries that use abundant XML structure, you can use operator `INPATH` plus a text path instead of nested `WITHIN` operators.

Operator `INPATH` takes a `text_query` on the left and a Text Path, enclosed in parentheses, on the right. Example E–17 finds `purchaseOrders` that contain the word "`electric`" in the path `/purchaseOrder/items/item/comment`.

Example E–17 Structure Inside Full-Text Predicate: INPATH

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items/item/comment)') > 0;
```

The scope of the search in Example E–17 is the section indicated by the Text Path. The query in Example E–18 uses a broader path than the query in Example E–17, but it too returns one row.

Example E–18 Structure Inside Full-Text Predicate: INPATH

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items)') > 0;
```

Using a Text Path The syntax and semantics of Text Path are based on the w3c XPath 1.0 recommendation. Simple path expressions are supported (abbreviated syntax only), but functions are not. The following examples are meant to give the general flavor.

See Also:

- `http://www.w3.org/TR/xpath` for information about the W3C XPath 1.0 recommendation
- "Text Path BNF Specification" on page E-26 for the Text Path grammar

Example E–19 finds all purchase orders that contain the word "`electric`" in a `comment` element that is the child of an `item` element with a `partNum` attribute whose value is "`872-AA`", which in turn is the child of an `items` element that is any number of levels under the root node.

Example E–19 INPATH with Complex Path Expression (1)

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (//items/item[@partNum="872-AA"]/comment)')
        > 0;
```

Example E–20 finds all purchase orders that contain the word "`lawnmower`" in a third-level `item` element (or any of its descendants) that has a `comment` element descendant at any level. This query returns one row. The scope of the query is *not* a `comment` element, but the set of `items` elements that each have a `comment` element as a descendant.

Example E–20 INPATH with Complex Path Expression (2)

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'lawnmower INPATH (/*/*/item[.//comment])') > 0;
```

Text Path Compared to XPath The Text Path language differs from the XPath language in the following ways:

- Not all XPath operators are included in the Text Path language.
- XPath built-in functions are not included in the Text Path language.
- Text Path language operators are case-insensitive.
- If you use = inside a filter (brackets), then matching follows text-matching rules.

  Rules for case-sensitivity, normalization, stopwords and whitespace depend on the text index definition. To emphasize this difference, this kind of equality is referred to here as text-equals.
- Namespace support is not included in the Text Path language.

  The name of an element, including a namespace prefix if it exists, is treated as a string. So two different namespace prefixes that map to the same namespace URI are not treated as equivalent in the Text Path language.
- In a Text Path, the context is always the root node of the document.

So in the purchase-order data, `purchaseOrder/items/item`, `/purchaseOrder/items/item`, and `./purchaseOrder/items/item` are all equivalent.

- If you want to search within an attribute value, then the direct parent of the attribute must be specified (wildcards cannot be used).
- A Text Path may not end in a wildcard (`*`).

> **See Also:** "Text Path BNF Specification" on page E-26 for the Text Path grammar

Using Nested INPATH You can nest `INPATH` expressions. The context for the Text Path is always the root node. It is not changed by a nested `INPATH`.

Example E–21 finds purchase orders that contain the word "`electric`" inside a `comment` element at any level, where the occurrence of that word is also in an `items` element that is a child of the top-level `purchaseOrder` element.

Example E–21 Nested INPATH

```
SELECT id FROM purchase_orders
  WHERE contains(doc,
                 '(electric INPATH (//comment)) INPATH (/purchaseOrder/items)')
        > 0;
```

This nested `INPATH` query could be written more concisely as shown in Example E–22.

Example E–22 Nested INPATH Rewritten

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items//comment)') > 0;
```

Using Structure Operator HASPATH

Operator `HASPATH` takes only one operand: a Text Path, enclosed in parentheses, on the right. Use `HASPATH` when you want to find documents that contain a particular section in a particular path, possibly with predicate `=`. This is a path search rather than a full-text search. You can check for the existence of a section, or you can match the contents of a section, but you cannot do word searches. If your data is of type `XMLType`, then consider using SQL/XML function `XMLExists` instead of structure operator `HASPATH`.

Example E–23 finds `purchaseOrders` that have some item that has a `USPrice`.

Example E–23 Simple HASPATH

```
SELECT id FROM purchase_orders
  WHERE contains(DOC, 'HASPATH (/purchaseOrder//item/USPrice)') > 0;
```

Example E–24 finds `purchaseOrders` that have some item that has a `USPrice` that text-equals "`148.95`".

> **See Also:** "Text Path Compared to XPath" on page E-10 for an explanation of text-equals

Example E–24 HASPATH Equality

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'HASPATH (/purchaseOrder//item/USPrice="148.95")') > 0;
```

HASPATH can be combined with other contains operators such as INPATH. Example E–25 finds purchaseOrders that contain the word electric anywhere in the document *and* have some item that has a USPrice that text-equals 148.95 *and* contain 10 in the purchaseOrder attribute orderDate.

Example E–25 HASPATH with Other Operators

```
SELECT id FROM purchase_orders
  WHERE contains(doc,
                 'electric
                  AND HASPATH (/purchaseOrder//item/USPrice="148.95")
                  AND 10 INPATH (/purchaseOrder/@orderDate)')
        > 0;
```

Projecting the CONTAINS Result

The result of a SQL query with a contains expression in the WHERE clause is always a set of rows (and possibly score information), or a projection over the rows that match the query.

If you want to return only a part of each XML document that satisfies a contains expression, then use SQL/XML function XMLQuery. The examples in this section use the XMLType table purchase_orders_xmltype.

Example E–26 finds purchaseOrders that contain the word "electric" inside a comment element that is a descendant of the top-level element purchaseOrder. Instead of returning the ID of the row for each result, XMLQuery is used to return only the comment element.

Example E–26 Scoping the Results of a CONTAINS Query

```
SELECT XMLQuery('declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
                 $d/purchaseOrder//comment'
                PASSING doc AS "d" RETURNING CONTENT) "Item Comment"
  FROM purchase_orders_xmltype
  WHERE CONTAINS(doc, 'electric INPATH (/purchaseOrder//comment)') > 0;
```

The result of Example E–26 is *two* instances of element comment. Function contains indicates which rows contain the word "electric" inside a comment element (the row with ID = 1), and function XMLQuery extracts all of the instances of element comment in the document at that row. There are two instances of element comment inside the purchaseOrder element, and the query returns both of them.

This might not be what you want. If you want the query to return only the instances of element comment that satisfy the contains expression, then you must repeat that predicate in the XQuery expression passed to XMLQuery. You do that using XPath function ora:contains. Example E–27 illustrates this.

Example E–27 Projecting the Result of a CONTAINS Query Using ora:contains

```
SELECT XMLQuery('declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
                 $d/purchaseOrder/items/item/comment
                   [ora:contains(text(), "electric") > 0]'
                PASSING doc AS "d" RETURNING CONTENT) "Item Comment"
  FROM purchase_orders_xmltype
  WHERE CONTAINS(doc, 'electric INPATH (/purchaseOrder/items/item/comment)') > 0;
```

CONTEXT Index

This section contains these topics:

Using CONTEXT Indexes

The general-purpose full-text index type is CONTEXT, which is owned by database user CTXSYS. To create a default full-text index, use the regular SQL CREATE INDEX command, and add the clause INDEXTYPE IS CTXSYS.CONTEXT, as shown in Example E–28.

Example E–28 Simple CONTEXT Index on Table PURCHASE_ORDERS

```
CREATE INDEX po_index ON purchase_orders(doc)
  INDEXTYPE IS CTXSYS.CONTEXT;
```

You have many choices available when building a full-text index. These choices are expressed as indexing **preferences**. To use an indexing preference, add the PARAMETERS clause to CREATE INDEX, as shown in Example E–29.

> **See Also:** "CONTEXT Index Preferences" on page E-14

Example E–29 Simple CONTEXT Index on XMLType Table with Path Section Group

```
CREATE INDEX po_index ON purchase_orders(doc)
  INDEXTYPE IS CTXSYS.CONTEXT
  PARAMETERS ('section group CTXSYS.PATH_SECTION_GROUP');
```

Oracle Text provides other index types, such as CTXCAT and CTXRULE, which are outside the scope of this chapter.

> **See Also:** *Oracle Text Reference* for more information about CONTEXT indexes

Using a CONTEXT Index on an XMLType Table You can build a CONTEXT index on any data that contains text. Example E–28 creates a CONTEXT index on a VARCHAR2 column. The syntax to create a CONTEXT index on a column of type CHAR, VARCHAR, VARCHAR2, BLOB, CLOB, BFILE, XMLType, or URIType is the same. Example E–30 creates a CONTEXT index on a column of type XMLType. The section group defaults to PATH_SECTION_GROUP.

Example E–30 Simple CONTEXT Index on XMLType Column

```
CREATE INDEX po_index_xmltype ON purchase_orders_xmltype(doc)
  INDEXTYPE IS CTXSYS.CONTEXT;
```

If you have an XMLType table, then you must use object syntax to create the CONTEXT index, as shown in Example E–31.

Example E–31 Simple CONTEXT Index on XMLType Table

```
CREATE INDEX po_index_xmltype_table
  ON purchase_orders_xmltype_table (OBJECT_VALUE)
  INDEXTYPE IS CTXSYS.CONTEXT;
```

You can query the table as shown in Example E–32.

Example E–32 CONTAINS Query on XMLType Table

```
SELECT XMLCast(XMLQuery(
                 'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
                  $p/purchaseOrder/@orderDate'
                 PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
               AS DATE) "Order Date"
  FROM purchase_orders_xmltype_table po
  WHERE contains(po.OBJECT_VALUE, 'electric INPATH (/purchaseOrder//comment)')
        > 0;
```

Maintaining a CONTEXT Index The CONTEXT index, like most full-text indexes, is asynchronous. When indexed data is changed, the CONTEXT index might not change until you take some action, such as calling a procedure to synchronize the index.

The CONTEXT index can become fragmented over time. A fragmented index uses more space and leads to slower queries. There are a number of ways to optimize (defragment) the CONTEXT index.

> **See Also:** *Oracle Text Reference* for more information about CONTEXT index maintenance

Roles and Privileges for CONTEXT Indexing You do not need any special privileges to create a CONTEXT index. You need the CTXAPP role to create and delete preferences and to use the Oracle Text PL/SQL packages. You must also have EXECUTE privilege on the CTXSYS package CTX_DDL.

Effect of a CONTEXT Index on CONTAINS

To use Oracle SQL function contains, you must create an index of type CONTEXT. If you call contains, and the column given in the first argument does not have an index of type CONTEXT, then an error is raised.

The syntax and semantics of text_query depend on the choices you make when you build the CONTEXT index. For example:

- What counts as a word?
- Are very common words processed?
- What is a common word?
- Is the text search case-sensitive?
- Can the text search include themes (concepts) in addition to keywords?

CONTEXT Index Preferences

A preference can be considered a collection of indexing choices. Preferences include section group, datastore, filter, wordlist, stoplist and storage. This section shows how to set up a lexer preference to make searches case-sensitive.

You can use procedure CTX_DDL.create_preference (or CTX_DDL.create_stoplist) to create a preference. Override default choices in that preference group by setting attributes of the new preference, using procedure CTX_DDL.set_attribute. Then use the preference in a CONTEXT index by including *preference type preference_name* in the PARAMETERS string of CREATE INDEX.

Once a preference has been created, you can use it to build any number of indexes.

Making Search Case-Sensitive Full-text searches with contains are *case-insensitive* by default. That is, when matching words in text_query against words in the document,

case is not considered. Section names and attribute names, however, are always *case-sensitive*.

If you want full-text searches to be case-sensitive, then you need to make that choice when building the CONTEXT index. Example E–33 returns 1 row, because "HURRY" in text_query matches "Hurry" in the purchaseOrder with the default case-insensitive index.

Example E–33 CONTAINS: Default Case Matching

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'HURRY INPATH (/purchaseOrder/comment)') > 0;
```

Example E–34 creates a new lexer preference my_lexer, with the attribute mixed_case set to TRUE. It also sets printjoin characters to "-" and "!" and ",". You can use the same preferences for building CONTEXT indexes and for building policies.

See Also: *Oracle Text Reference* for a full list of lexer attributes

Example E–34 Create a Preference for Mixed Case

```
BEGIN
  CTX_DDL.create_preference(PREFERENCE_NAME  =>  'my_lexer',
                            OBJECT_NAME      =>  'BASIC_LEXER');

  CTX_DDL.set_attribute(PREFERENCE_NAME  =>  'my_lexer',
                        ATTRIBUTE_NAME   =>  'mixed_case',
                        ATTRIBUTE_VALUE  =>  'TRUE');

  CTX_DDL.set_attribute(PREFERENCE_NAME  =>  'my_lexer',
                        ATTRIBUTE_NAME   =>  'printjoins',
                        ATTRIBUTE_VALUE  =>  '-,!');
END;
/
```

Example E–35 builds a CONTEXT index using the new my_lexer lexer preference. It uses preference preference-case-mixed.

Example E–35 CONTEXT Index on PURCHASE_ORDERS Table, Mixed Case

```
CREATE INDEX po_index ON purchase_orders(doc)
  INDEXTYPE IS CTXSYS.CONTEXT
  PARAMETERS('lexer my_lexer section group CTXSYS.PATH_SECTION_GROUP');
```

Example E–33 returns no rows, because "HURRY" in text_query no longer matches "Hurry" in the purchaseOrder. Example E–36 returns one row, because the text_query term "Hurry" exactly matches the word "Hurry" in the purchaseOrder.

Example E–36 CONTAINS: Mixed (Exact) Case Matching

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'Hurry INPATH (/purchaseOrder/comment)') > 0;
```

Introduction to Section Groups

One of the choices you make when creating a CONTEXT index is section group. A section group instance is based on a section group type. The section group type specifies the kind of structure in your documents, and how to index (and therefore search) that structure. The section group instance may specify which structure elements are indexed. Most users either take the default section group or use a predefined section group.

Choosing a Section Group Type The section group types useful in XML searching are:

- PATH_SECTION_GROUP

  Choose this when you want to use WITHIN, INPATH and HASPATH in queries, and you want to be able to consider all sections to scope the query.

- XML_SECTION_GROUP

  Choose this when you want to use WITHIN, but not INPATH and HASPATH, in queries, and you want to be able to consider only explicitly-defined sections to scope the query. XML_SECTION_GROUP section group type supports FIELD sections in addition to ZONE sections. In some cases FIELD sections offer significantly better query performance.

- AUTO_SECTION_GROUP

  Choose this when you want to use WITHIN, but not INPATH and HASPATH, in queries, and you want to be able to consider most sections to scope the query. By default all sections are indexed (available for query restriction). You can specify that some sections are *not* indexed (by defining STOP sections).

- NULL_SECTION_GROUP

  Choose this when defining no XML sections.

Other section group types include:

- BASIC_SECTION_GROUP
- HTML_SECTION_GROUP
- NEWS_SECTION_GROUP

Oracle recommends that most users with XML full-text search requirements use PATH_SECTION_GROUP. Some users might prefer XML_SECTION_GROUP with FIELD sections. This choice generally gives better query performance and a smaller index, but it is limited to documents with fielded structure (searchable nodes are all leaf nodes that do not repeat).

> **See Also:** *Oracle Text Reference* for a detailed description of the XML_SECTION_GROUP section group type

Choosing a Section Group When choosing a section group to use with your index, you can choose a supplied section group, take the default, or create a new section group based on the section group type you have chosen.

There are supplied section groups for section group types PATH_SECTION_GROUP, AUTO_SECTION_GROUP, and NULL_SECTION_GROUP. The supplied section groups are owned by CTXSYS and have the same name as their section group types. For example, the supplied section group of section group type PATH_SECTION_GROUP is CTXSYS.PATH_SECTION_GROUP.

There is no supplied section group for section group type XML_SECTION_GROUP, because a default XML_SECTION_GROUP would be empty and therefore meaningless. If you want to use section group type XML_SECTION_GROUP, then you must create a new section group and specify each node that you want to include as a section.

When you create a CONTEXT index on data of type XMLType, the default section group is the supplied section group CTXSYS.PATH_SECTION_GROUP. If the data is VARCHAR or CLOB, then the default section group is CTXSYS.NULL_SECTION_GROUP.

See Also: *Oracle Text Reference* for instructions on creating your own section group

To associate a section group with an index, add `section group <section group name>` to the `PARAMETERS` string, as in Example E–37.

Example E–37 Simple CONTEXT Index on purchase_orders Table with Path Section Group

```
CREATE INDEX po_index ON purchase_orders(doc)
  INDEXTYPE IS CTXSYS.CONTEXT
  PARAMETERS ('section group CTXSYS.PATH_SECTION_GROUP');
```

ora:contains XQuery Function

Function `ora:contains` is an Oracle-defined XQuery (XPath) function for use in the XQuery expression argument to SQL/XML functions `XMLQuery`, `XMLTable`, and `XMLExists`.

When you use `ora:contains` you must also supply a namespace declaration that maps prefix `ora` to the Oracle XML DB namespace, `xmlns:ora="http://xmlns.oracle.com/xdb"`.

Function `ora:contains` returns a number. It does *not* return a score. It returns a positive number if the `text_query` matches the `input_text`. Otherwise it returns zero.

Full-Text Search Using XQuery Function ora:contains

The `ora:contains` argument *`text_query`* is a string that specifies the full-text search. The `ora:contains` *`text_query`* is the same as the `contains` *`text_query`*, with the following restrictions:

- `ora:contains` *`text_query`* must *not* include any of the structure operators `WITHIN`, `INPATH`, or `HASPATH`
- `ora:contains` *`text_query`* can include the score weighting operator `weight(*)`, but weights are *ignored*

If you include any of the following in the `ora:contains` *`text_query`*, the query *cannot* use a `CONTEXT` index:

- Score-based operator `MINUS` (`-`) or `threshold` (`>`)
- Selective, corpus-based expansion operator `FUZZY` (`?`) or `soundex` (`!`)

See Also: "XPath Rewrite and CONTEXT Indexes" on page E-23

Example E–4 shows a full-text search using an arbitrary combination of Boolean operators and `$` (stemming).

See Also:

- "Full-Text Search Using SQL Function CONTAINS" on page E-5 for a description of full-text operators
- *Oracle Text Reference* for a full list of the operators you can use in `contains` and `ora:contains`

Matching rules are defined by the *policy*, *`policy_owner.policy_name`*. If *`policy_owner`* is absent, then the policy owner defaults to the current user. If both *`policy_name`* and

policy_owner are absent, then the policy defaults to CTXSYS.DEFAULT_POLICY_ORACONTAINS.

Scope of an ora:contains Query

When you use ora:contains in an XPath expression, the scope is defined by argument *input_text*. This argument is evaluated in the current XPath context. If the result is a single text node or an attribute, then that node is the target of the ora:contains search. If *input_text* does not evaluate to a single text node or an attribute, an error is raised.

The policy determines the matching rules for ora:contains. The section group associated with the default policy for ora:contains is of type NULL_SECTION_GROUP.

You can use ora:contains anywhere in an XPath expression, and its *input_text* argument can be any XPath expression that evaluates to a single text node or an attribute.

Projecting the ora:contains Result

If you want to return only a part of each XML document, then use function XMLQuery to project a node sequence, possibly applying XMLCast to the result to project the scalar value of a node.

Example E–38 returns the orderDate for each purchase order that has a comment that contains the word "lawn".

Example E–38 Using ora:contains with XMLQuery and XMLExists

```
SELECT XMLCast(XMLQuery(
                 'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
                  $d/purchaseOrder/@orderDate'
                 PASSING doc AS "d" RETURNING CONTENT)
               AS DATE) "Order date"
  FROM purchase_orders_xmltype
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/comment
             [ora:contains(text(), "($lawns AND wild) OR flamingo") > 0]'
          PASSING doc AS "d");
```

Function XMLExists restricts the result to rows (documents) where the purchaseOrder element includes some comment that contains the word "lawn". Function XMLQuery then returns the value of attribute orderDate from those purchaseOrder elements. Function XMLCast casts this result as a SQL DATE value.

If //comment had been extracted, then both comments from the sample document would have been returned, not just the comment that matches the WHERE clause.

> **See Also:** Example E–26, "Scoping the Results of a CONTAINS Query" on page E-12

Using Policies with ora:contains Queries

The CONTEXT index on a column determines the semantics of contains queries on that column. Because ora:contains does not rely on a supporting index, some other means must be found to provide many of the same choices when doing ora:contains queries. A **policy** is a collection of preferences that can be associated with an ora:contains query to give the same sort of semantic control as the indexing choices give to the contains user.

Using a Policy with ora:contains Queries for Stopwords

When using Oracle SQL function `contains`, indexing preferences affect the semantics of the query. You create a preference using procedure `CTX_DDL.create_preference` (or `CTX_DDL.create_stoplist`). You override default choices by setting attributes of the new preference, using procedure `CTX_DDL.set_attribute`. Then you use the preference in a `CONTEXT` index by including *`preference_type preference_name`* in the `PARAMETERS` string of `CREATE INDEX`.

See Also: "CONTEXT Index Preferences" on page E-14

Because `ora:contains` does not have a supporting index, a different mechanism is needed to apply preferences to a query. That mechanism is a policy, consisting of a collection of preferences, and it is used as a parameter to `ora:contains`.

Policy Example: Supplied Stoplist Example E–39 creates a policy with an empty stopwords list.

Example E–39 Create a Policy to Use with ora:contains

```
BEGIN
  CTX_DDL.create_policy(POLICY_NAME  =>  'my_nostopwords_policy',
                        STOPLIST     =>  'CTXSYS.EMPTY_STOPLIST');
END;
/
```

For simplicity, this policy consists of an empty stoplist, which is owned by user `CTXSYS`. You could create a new stoplist to include in this policy, or you could reuse a stoplist (or lexer) definition that you created for a `CONTEXT` index.

Refer to this policy in an `ora:contains` expression to search for all words, including the most common ones (stopwords). Example E–40 returns zero comments, because "`is`" is a stopword by default and cannot be queried.

Example E–40 Finding a Stopword Using ora:contains

```
SELECT id FROM purchase_orders_xmltype
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/comment[ora:contains(text(), "is") > 0]'
          PASSING doc AS "d");
```

Example E–41 uses the policy created in Example E–39 to specify an empty stopword list. This query finds "`is`" and returns 1 comment.

Example E–41 Finding a Stopword Using ora:contains and Policy my_nostopwords_policy

```
SELECT id FROM purchase_orders_xmltype
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/comment
             [ora:contains(text(), "is", "MY_NOSTOPWORDS_POLICY") > 0]'
          PASSING doc AS "d");
```

Example E–41 uses policy `my_nostopwords_policy`. This policy was implicitly named as all uppercase, in Example E–39. Because XPath is case-sensitive, it must be referred to in the XPath predicate using all uppercase: `MY_NOSTOPWORDS_POLICY`, not `my_nostopwords_policy`.

Effect of Policies on ora:contains

The `ora:contains` policy affects the matching semantics of `text_query`. The `ora:contains` policy may include a lexer, stoplist, wordlist preference, or any combination of these. Other preferences that can be used to build a `CONTEXT` index are not applicable to `ora:contains`. The effects of the preferences are as follows:

- The wordlist preference tweaks the semantics of the stem operator.
- The stoplist preference defines which words are too common to be indexed (searchable).
- The lexer preference defines how words are tokenized and matched. For example, it defines which characters count as part of a word and whether matching is case-sensitive.

See Also:

- "Policy Example: Supplied Stoplist" on page E-19 for an example of building a policy with a predefined stoplist
- "Policy Example: User-Defined Lexer" on page E-20 for an example of a case-sensitive policy

Policy Example: User-Defined Lexer When you search for a document that contains a particular word, you usually want the search to be case-insensitive. If you do a search that is case-sensitive, then you often miss some expected results. For example, if you search for `purchaseOrders` that contain the phrase "baby monitor", then you would not expect to miss our example document just because the phrase is written "Baby Monitor".

Full-text searches with `ora:contains` are case-insensitive by default. Section names and attribute names, however, are always case-sensitive.

If you want full-text searches to be case-sensitive, then you need to make that choice when you create a policy. You can use this procedure:

1. Create a preference using the procedure `CTX_DDL.create_preference` (or `CTX_DDL.create_stoplist`).
2. Override default choices in that preference object by setting attributes of the new preference, using procedure `CTX_DDL.set_attribute`.
3. Use the preference as a parameter to `CTX_DDL.create_policy`.
4. Use the policy name as the third argument to `ora:contains` in a query.

Once you have created a preference, you can reuse it in other policies or in `CONTEXT` index definitions. You can use any policy with any `ora:contains` query.

Example E–42 returns 1 row, because "`HURRY`" in `text_query` matches "`Hurry`" in the `purchaseOrder` with the default case-insensitive index.

Example E–42 ora:contains, Default Case-Sensitivity

```
SELECT id FROM purchase_orders_xmltype
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/comment[ora:contains(text(), "HURRY") > 0]'
          PASSING doc AS "d");
```

Example E–43 creates a new lexer preference `my_lexer`, with the attribute `mixed_case` set to `TRUE`. It also sets `printjoin` characters to "-", "!" and ",". You can use the same preferences for building `CONTEXT` indexes and for building policies.

See Also: *Oracle Text Reference* for a full list of lexer attributes

Example E–43 Create a Preference for Mixed Case

```
BEGIN
  CTX_DDL.create_preference(PREFERENCE_NAME  =>  'my_lexer',
                            OBJECT_NAME      =>  'BASIC_LEXER');
  CTX_DDL.set_attribute(PREFERENCE_NAME  =>  'MY_LEXER',
                        ATTRIBUTE_NAME   =>  'MIXED_CASE',
                        ATTRIBUTE_VALUE  =>  'TRUE');
  CTX_DDL.set_attribute(PREFERENCE_NAME  =>  'my_lexer',
                        ATTRIBUTE_NAME   =>  'printjoins',
                        ATTRIBUTE_VALUE  =>  '-,!');
END;
/
```

Example E–44 creates a new policy `my_policy` and specifies only the lexer. All other preferences are defaulted. Example E–44 uses `preference-case-mixed`.

Example E–44 Create a Policy with Mixed Case (Case-Insensitive)

```
BEGIN
  CTX_DDL.create_policy(POLICY_NAME  => 'my_policy',
                        LEXER        => 'my_lexer');
END;
/
```

Example E–45 uses the new policy in a query. It returns no rows, because "`HURRY`" in `text_query` no longer matches "`Hurry`" in the `purchaseOrder`.

Example E–45 ora:contains, Case-Sensitive (1)

```
SELECT id FROM purchase_orders_xmltype
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/comment
             [ora:contains(text(), "HURRY", "my_policy") > 0]'
          PASSING doc AS "d");
```

Example E–46 returns one row, because the `text_query` term "`Hurry`" exactly matches the text "`Hurry`" in the `comment` element.

Example E–46 ora:contains, Case-Sensitive (2)

```
SELECT id FROM purchase_orders_xmltype
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/comment[ora:contains(text(), "Hurry") > 0]'
          PASSING doc AS "d");
```

Policy Defaults

The policy argument to `ora:contains` is optional. If it is omitted, then the query uses the default policy `CTXSYS.DEFAULT_POLICY_ORACONTAINS`.

When you create a policy for use with `ora:contains`, you do not need to specify every preference. In Example E–44 on page E-21, for example, only the lexer preference was

specified. For the preferences that are not specified, CREATE_POLICY uses the default preferences:

- CTXSYS.DEFAULT_LEXER
- CTXSYS.DEFAULT_STOPLIST
- CTXSYS.DEFAULT_ WORDLIST

Creating a policy follows copy semantics for preferences and their attributes, just as creating a CONTEXT index follows copy semantics for index metadata.

Improving the Performance of ora:contains

The ora:contains XPath function does not depend on a supporting index. ora:contains is very flexible. But if you use it to search across large amounts of data without an index, then it can also be resource-intensive. This section shows how to get the best performance from queries that include XPath expressions with XPath function ora:contains.

> **Note:** Function-based indexes can also be very effective in speeding up XML queries, but they are not generally applicable to Text queries.

The examples in this section use table purchase_orders_xmltype_big. This has the same table structure and XML schema as purchase_orders_xmltype, but it has around 1,000 rows. Each row has a unique ID (in column id), and some different text in /purchaseOrder/items/item/comment. Where an execution plan is shown, it was produced using the SQL*Plus command AUTOTRACE. Execution plans can also be produced using SQL commands TRACE and TKPROF. A description of commands AUTOTRACE, trace and tkprof is outside the scope of this chapter.

This section contains these topics:

- Using a Primary Filter in the Query
- XPath Rewrite and CONTEXT Indexes

Using a Primary Filter in the Query

Because ora:contains is relatively costly to process, Oracle recommends that you write queries that include a primary filter wherever possible. This minimizes the number of rows processed by ora:contains.

Example E–47 examines each row in a table (a full table scan), as shown by the execution plan. In this example, ora:contains is evaluated for each row.

Example E–47 ora:contains in Large Table

```
SELECT id FROM purchase_orders_xmltype_big
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/comment[ora:contains(text(), "constitution") > 0]'
          PASSING doc AS "d");
```

```
Execution Plan
----------------------------------------------------------------------------------------------
| Id | Operation                     | Name                     |Rows|Bytes|Cost(%CPU)| Time|
----------------------------------------------------------------------------------------------
|   0| SELECT STATEMENT              |                          |  32|64480|686(38)|00:00:09|
|*  1| FILTER                        |                          |    |     |       |        |
```

```
|   2|TABLE ACCESS FULL               |PURCHASE_ORDERS_XMLTYPE_BIG|1161|2284K| 140(3)|00:00:02|
|*  3|COLLECTION ITERATOR PICKLER FETCH| XMLSEQUENCEFROMXMLTYPE    |    |      |       |        |
-----------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------
   1 - filter( EXISTS (SELECT 0 FROM TABLE() "KOKBF$" WHERE
             SYS_XMLCONTAINS(SYS_XQ_UPKXML2SQL(SYS_XQEXVAL(SYS_XQEXTRACT(SYS_XQCON2SEQ(VALUE(KOKBF$)),
             '/comment/text()'),1,50),50,1,0),'constitution')>0))
   3 - filter(SYS_XMLCONTAINS(SYS_XQ_UPKXML2SQL(SYS_XQEXVAL(SYS_XQEXTRACT(SYS_XQCON2SEQ(VALUE(KOKBF$)),
             '/comment/text()'),1,50),50,1,0),'constitution')>0)

Note
-----
   - dynamic sampling used for this statement
```

If you create an index on column `id`, as shown in Example E–48, and you add a selective predicate `id` to the query, as shown in Example E–49, then index `id` drives the execution, as shown in the execution plan. Function `ora:contains` is then executed only for the rows where `id` is less than 5.

Example E–48 B-tree Index on ID

```
CREATE INDEX id_index ON purchase_orders_xmltype_big(id);
```

Example E–49 ora:contains in Large Table, with Additional Predicate

```
SELECT id FROM purchase_orders_xmltype_big
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/comment[ora:contains(text(), "constitution") > 0]'
          PASSING doc AS "d")
    AND id > 5;
```

```
Execution Plan
-----------------------------------------------------------------------------------------------
| Id  | Operation                   | Name                       |Rows| Bytes |Cost(%CPU)| Time|
-----------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT            |                            |  1 |  2015 |8  (13)|00:00:01|
|*  1 |  TABLE ACCESS BY INDEX ROWID|PURCHASE_ORDERS_XMLTYPE_BIG|  1 |  2015 |8  (13)|00:00:01|
|*  2 |   INDEX RANGE SCAN          |ID_INDEX                    | 10 |       |2   (0)|00:00:01|
-----------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter(EXISTSNODE(SYS_MAKEXML("PURCHASE_ORDERS_XMLTYPE_BIG"."SYS_NC00003$
       "),'/purchaseOrder/items/item/comment[ora:contains(text(), "constitution") >
              0]','xmlns:ora="http://xmlns.oracle.com/xdb"')=1)
   2 - access("ID">5)

Note
-----
   - dynamic sampling used for this statement
```

XPath Rewrite and CONTEXT Indexes

Oracle Database can sometimes optimize a query that makes use of an XPath expression. This XPath rewriting is done automatically as part of query optimization.

Although Oracle XQuery function `ora:contains` does not rely on a supporting index, when XPath rewrite occurs `ora:contains` can often make use of an existing `CONTEXT` index for better performance.

See Also: Chapter 19, "XPath Rewrite for Object-Relational Storage"

Example E–50 ora:contains Search for "electric"

```
SELECT id FROM purchase_orders_xmltype
  WHERE XMLExists(
          'declare namespace ora = "http://xmlns.oracle.com/xdb"; (: :)
           $d/purchaseOrder/items/item/comment
             [ora:contains(text(), "electric") > 0]'
          PASSING doc AS "d");
```

A naive evaluation of the XPath expression in Example E–50 would test each cell in column `doc` to see if it matches that expression.

But if `doc` is XML schema-based and the `purchaseOrder` documents are physically stored in object-relational `XMLType` tables, then it makes sense to go straight to column `comment` (if such a column exists) and test each cell there to see if it matches `"electric"`.

If the first argument to `ora:contains` maps to a single relational column, then `ora:contains` can be applied to that column, instead of applying the complete XPath expression to the entire XML document. Even if there are no indexes involved, this can significantly improve query performance.

If you are using `ora:contains` with a text node or an attribute that maps to a column that has a `CONTEXT` index then that index can sometimes be applied to the data in the underlying column. The following conditions must both be true, in order for a `CONTEXT` index to be used with object-relational `XMLType` data.

- The `ora:contains` target (`input_text`) must be either (a) a single text node whose parent node maps to a column or (b) an attribute that maps to a column. The column must be a single relational column (possibly in an ordered collection table).
- As noted in "Using Policies with ora:contains Queries" on page E-18, the indexing choices (for `contains`) and the policy choices (for `ora:contains`) affect the semantics of queries. A simple mismatch might be that the index-based `contains` would do a *case-sensitive* search, while `ora:contains` specifies a *case-insensitive* search. To ensure that the `ora:contains` and the rewritten `contains` have the same semantics, the `ora:contains` policy must exactly match the index choices of the `CONTEXT` index.

Both the `ora:contains` policy and the `CONTEXT` index must also use the `NULL_SECTION_GROUP` section group type. The default section group for an `ora:contains` policy is `ctxsys.NULL_SECTION_GROUP`.

Finally, a `CONTEXT` index is generally asynchronous. If you add a new document that contains the word `"dog"`, but you do not synchronize the `CONTEXT` index, then a `contains` query for `"dog"` does not return that document. But an `ora:contains` query against the same data does. To ensure that the `ora:contains` and the rewritten SQL `contains` always return the same results, build the `CONTEXT` index with the `TRANSACTIONAL` keyword in the `PARAMETERS` string.

See Also: *Oracle Text Reference* for information about creating a `CONTEXT` index that is transactional using `ALTER INDEX` with parameter `TRANSACTIONAL`

A query with XMLQuery, XMLTable or XMLExists, where the XPath expression includes ora:contains, can be considered for XPath rewrite if the ora:contains policy exactly matches the index choices of the CONTEXT index and if either of these conditions is true:

- The XML data is stored *object-relationally*; the first ora:contains argument (input_text) is either a single text node whose parent node maps to a single relational column or an attribute that maps to a single relational column; there is a transactional CONTEXT index on that column.
- The XML data is *binary XML* that is indexed by an XMLIndex index, and there is a CONTEXT index on either the path-table VALUE column of an unstructured XMLIndex component or a scalar-value column of a structured XMLIndex component.

  If the CONTEXT index is non-transactional then you must also use XQuery extension-expression pragma ora:use_text_index, to force the use of the CONTEXT index. Example E–51 illustrates this.

Example E–51 Using XQuery Pragma ora:use_text_index with ora:contains

```
CREATE INDEX po_otext_ix ON my_path_table (VALUE) INDEXTYPE IS CTXSYS.CONTEXT;

EXPLAIN PLAN FOR
  SELECT DISTINCT XMLCast(XMLQuery('$p/PurchaseOrder/ShippingInstructions/address'
                                   PASSING po.OBJECT_VALUE AS "p" RETURNING CONTENT)
                          AS VARCHAR2(256)) "Address"
    FROM po_binxml po
    WHERE XMLExists(
            '$p/PurchaseOrder/ShippingInstructions/address
               [(# ora:use_text_index #) {ora:contains(., "$(Fortieth)")} > 0]'
            PASSING po.OBJECT_VALUE AS "p");

-----------------------------------------------------------------------------------------------------------
| Id  | Operation                           | Name                          | Rows | Bytes|Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                    |                               |    1 | 3046 |   12  (17)|00:00:01|
|   1 |  SORT GROUP BY                      |                               |    1 | 3524 |           |        |
|*  2 |   TABLE ACCESS BY INDEX ROWID BATCHED| MY_PATH_TABLE                |    2 | 7048 |    3   (0)|00:00:01|
|*  3 |    INDEX RANGE SCAN                 | SYS89559_PO_XMLINDE_PIKEY_IX  |    1 |      |    2   (0)|00:00:01|
|   4 |  HASH UNIQUE                        |                               |    1 | 3046 |   12  (17)|00:00:01|
|   5 |   NESTED LOOPS                      |                               |    1 | 3046 |    8  (13)|00:00:01|
|   6 |    SORT UNIQUE                      |                               |    1 | 3034 |    6   (0)|00:00:01|
|*  7 |     TABLE ACCESS BY INDEX ROWID     | MY_PATH_TABLE                 |    1 | 3034 |    6   (0)|00:00:01|
|*  8 |      DOMAIN INDEX                   | PO_OTEXT_IX                   |      |      |    4   (0)|00:00:01|
|   9 |    TABLE ACCESS BY USER ROWID       | PO_BINXML                     |    1 |   12 |    1   (0)|00:00:01|
-----------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - filter(SYS_XMLI_LOC_ISNODE("SYS_P3"."LOCATOR")=1)
   3 - access("SYS_P3"."RID"=:B1 AND "SYS_P3"."PATHID"=HEXTORAW('6F7F'))
   7 - filter("SYS_P1"."PATHID"=HEXTORAW('6F7F') AND SYS_XMLI_LOC_ISNODE("SYS_P1"."LOCATOR")=1)
   8 - access("CTXSYS"."CONTAINS"("SYS_P1"."VALUE",'$(Fortieth)')>0)

Note
-----
   - dynamic sampling used for this statement (level=2)

28 rows selected.
```

Example E–51 uses the XMLIndex index created in Example 6–10 on page 6-19. It creates a CONTEXT index on the VALUE column of the unstructured XMLIndex

component. The execution plan shows that both the XMLIndex index and the CONTEXT index are picked up. The former is indicated by the references to my_path_table and the pikey index, SYS89559_PO_XMLINDE_PIKEY_IX. The latter is indicated by the references to po_otext_ix and the predicate access mentioning CONTAINS.

Text Path BNF Specification

```
HasPathArg            ::=   LocationPath
                          |  EqualityExpr
InPathArg             ::=   LocationPath
LocationPath          ::=   RelativeLocationPath
                          |  AbsoluteLocationPath
AbsoluteLocationPath  ::=   ("/" RelativeLocationPath)
                          |  ("//" RelativeLocationPath)
RelativeLocationPath  ::=   Step
                          |  (RelativeLocationPath "/" Step)
                          |  (RelativeLocationPath "//" Step)
Step                  ::=   ("@" NCName)
                          |  NCName
                          |  (NCName Predicate)
                          |  Dot
                          |  "*"
Predicate             ::=   ("[" OrExp "]")
                          |  ("[" Digit+ "]")
OrExpr                ::=   AndExpr
                          |  (OrExpr "or" AndExpr)
AndExpr               ::=   BooleanExpr
                          |  (AndExpr "and" BooleanExpr)
BooleanExpr           ::=   RelativeLocationPath
                          |  EqualityExpr
                          |  ("(" OrExpr ")")
                          |  ("not" "(" OrExpr ")")
EqualityExpr          ::=   (RelativeLocationPath "=" Literal)
                          |  (Literal "=" RelativeLocationPath)
                          |  (RelativeLocationPath "=" Literal)
                          |  (Literal "!=" RelativeLocationPath)
                          |  (RelativeLocationPath "=" Literal)
                          |  (Literal "!=" RelativeLocationPath)
Literal               ::=   (DoubleQuote [~"]* DoubleQuote)
                          |  (SingleQuote [~']* SingleQuote)
NCName                ::=   (Letter |  Underscore) NCNameChar*
NCNameChar            ::=   Letter
                          |  Digit
                          |  Dot
                          |  Dash
                          |  Underscore
Letter                ::=   ([a-z] | [A-Z])
Digit                 ::=   [0-9]
Dot                   ::=   "."
Dash                  ::=   "-"
Underscore            ::=   "_"
```

Support for Full-Text XML Examples

This section contains these topics:

- Purchase-Order XML Document, po001.xml
- CREATE TABLE Statements

Purchase-Order XML Document, po001.xml

Example E–52 Purchase Order XML Document, po001.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<purchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:noNamespaceSchemaLocation="xmlschema/po.xsd"
               orderDate="1999-10-20">
  <shipTo country="US">
    <name>Alice Smith</name>
    <street>123 Maple Street</street>
    <city>Mill Valley</city>
    <state>CA</state>
    <zip>90952</zip>
  </shipTo>
  <billTo country="US">
    <name>Robert Smith</name>
    <street>8 Oak Avenue</street>
    <city>Old Town</city>
    <state>PA</state>
    <zip>95819</zip>
  </billTo>
  <comment>Hurry, my lawn is going wild!</comment>
  <items>
    <item partNum="872-AA">
      <productName>Lawnmower</productName>
      <quantity>1</quantity>
      <USPrice>148.95</USPrice>
      <comment>Confirm this is electric</comment>
    </item>
    <item partNum="926-AA">
      <productName>Baby Monitor</productName>
      <quantity>1</quantity>
      <USPrice>39.98</USPrice>
      <shipDate>1999-05-21</shipDate>
    </item>
  </items>
</purchaseOrder>
```

CREATE TABLE Statements

Example E–53 Create Table PURCHASE_ORDERS

```
CREATE TABLE purchase_orders (id NUMBER, doc VARCHAR2(4000));

INSERT INTO purchase_orders (id, doc)
  VALUES (1,
          '<?xml version="1.0" encoding="UTF-8"?>
           <purchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                          xsi:noNamespaceSchemaLocation="xmlschema/po.xsd"
                          orderDate="1999-10-20">
             <shipTo country="US">
               <name>Alice Smith</name>
               <street>123 Maple Street</street>
               <city>Mill Valley</city>
               <state>CA</state>
               <zip>90952</zip>
```

```
              </shipTo>
              <billTo country="US">
                <name>Robert Smith</name>
                <street>8 Oak Avenue</street>
                <city>Old Town</city>
                <state>PA</state>
                <zip>95819</zip>
              </billTo>
              <comment>Hurry, my lawn is going wild!</comment>
              <items>
                <item partNum="872-AA">
                  <productName>Lawnmower</productName>
                  <quantity>1</quantity>
                  <USPrice>148.95</USPrice>
                  <comment>Confirm this is electric</comment>
                </item>
                <item partNum="926-AA">
                  <productName>Baby Monitor</productName>
                  <quantity>1</quantity>
                  <USPrice>39.98</USPrice>
                  <shipDate>1999-05-21</shipDate>
                </item>
              </items>
            </purchaseOrder>');
COMMIT;
```

Example E–54 Create Table PURCHASE_ORDERS_XMLTYPE

```
CREATE TABLE purchase_orders_xmltype (id  NUMBER, doc XMLType);

INSERT INTO purchase_orders_xmltype (id, doc)
  VALUES (1,
          XMLTYPE ('<?xml version="1.0" encoding="UTF-8"?>
                     <purchaseOrder
                       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                       xsi:noNamespaceSchemaLocation="po.xsd"
                       orderDate="1999-10-20">
                       <shipTo country="US">
                         <name>Alice Smith</name>
                         <street>123 Maple Street</street>
                         <city>Mill Valley</city>
                         <state>CA</state>
                         <zip>90952</zip>
                       </shipTo>
                       <billTo country="US">
                         <name>Robert Smith</name>
                         <street>8 Oak Avenue</street>
                         <city>Old Town</city>
                         <state>PA</state>
                         <zip>95819</zip>
                       </billTo>
                       <comment>Hurry, my lawn is going wild!</comment>
                       <items>
                         <item partNum="872-AA">
                           <productName>Lawnmower</productName>
                           <quantity>1</quantity>
                           <USPrice>148.95</USPrice>
                           <comment>Confirm this is electric</comment>
                         </item>
                         <item partNum="926-AA">
```

```
                          <productName>Baby Monitor</productName>
                          <quantity>1</quantity>
                          <USPrice>39.98</USPrice>
                          <shipDate>1999-05-21</shipDate>
                        </item>
                      </items>
                    </purchaseOrder>'));
COMMIT;
```

Example E–55 Create Table PURCHASE_ORDERS_XMLTYPE_TABLE

```
CREATE TABLE purchase_orders_xmltype_table OF XMLType;

INSERT INTO purchase_orders_xmltype_table
  VALUES (
    XMLType ('<?xml version="1.0" encoding="UTF-8"?>
              <purchaseOrder
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xsi:noNamespaceSchemaLocation="xmlschema/po.xsd"
                orderDate="1999-10-20">
                <shipTo country="US">
                  <name>Alice Smith</name>
                  <street>123 Maple Street</street>
                  <city>Mill Valley</city>
                  <state>CA</state>
                  <zip>90952</zip>
                </shipTo>
                <billTo country="US">
                  <name>Robert Smith</name>
                  <street>8 Oak Avenue</street>
                  <city>Old Town</city>
                  <state>PA</state>
                  <zip>95819</zip>
                </billTo>
                <comment>Hurry, my lawn is going wild!</comment>
                <items>
                  <item partNum="872-AA">
                    <productName>Lawnmower</productName>
                    <quantity>1</quantity>
                    <USPrice>148.95</USPrice>
                    <comment>Confirm this is electric</comment>
                  </item>
                  <item partNum="926-AA">
                    <productName>Baby Monitor</productName>
                    <quantity>1</quantity>
                    <USPrice>39.98</USPrice>
                    <shipDate>1999-05-21</shipDate>
                  </item>
                </items>
              </purchaseOrder>'));
COMMIT;
```

Purchase-Order XML Schema for Full-Text Search Examples

Example E–56 Purchase-Order XML Schema for Full-Text Search Examples

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:annotation>
    <xsd:documentation xml:lang="en">
```

```
      Purchase order schema for Example.com.
      Copyright 2000 Example.com. All rights reserved.
    </xsd:documentation>
  </xsd:annotation>
  <xsd:element name="purchaseOrder" type="PurchaseOrderType"/>
  <xsd:element name="comment" type="xsd:string"/>
  <xsd:complexType name="PurchaseOrderType">
    <xsd:sequence>
      <xsd:element name="shipTo" type="USAddress"/>
      <xsd:element name="billTo" type="USAddress"/>
      <xsd:element ref="comment" minOccurs="0"/>
      <xsd:element name="items" type="Items"/>
    </xsd:sequence>
    <xsd:attribute name="orderDate" type="xsd:date"/>
  </xsd:complexType>
  <xsd:complexType name="USAddress">
    <xsd:sequence>
      <xsd:element name="name" type="xsd:string"/>
      <xsd:element name="street" type="xsd:string"/>
      <xsd:element name="city" type="xsd:string"/>
      <xsd:element name="state" type="xsd:string"/>
      <xsd:element name="zip" type="xsd:decimal"/>
    </xsd:sequence>
    <xsd:attribute name="country" type="xsd:NMTOKEN" fixed="US"/>
  </xsd:complexType>
  <xsd:complexType name="Items">
    <xsd:sequence>
      <xsd:element name="item" minOccurs="0" maxOccurs="unbounded">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="productName" type="xsd:string"/>
            <xsd:element name="quantity">
              <xsd:simpleType>
                <xsd:restriction base="xsd:positiveInteger">
                  <xsd:maxExclusive value="100"/>
                </xsd:restriction>
              </xsd:simpleType>
            </xsd:element>
            <xsd:element name="USPrice" type="xsd:decimal"/>
            <xsd:element ref="comment" minOccurs="0"/>
            <xsd:element name="shipDate" type="xsd:date" minOccurs="0"/>
          </xsd:sequence>
          <xsd:attribute name="partNum" type="SKU" use="required"/>
        </xsd:complexType>
      </xsd:element>
    </xsd:sequence>
  </xsd:complexType>
  <!-- Stock Keeping Unit, a code for identifying products -->
  <xsd:simpleType name="SKU">
    <xsd:restriction base="xsd:string">
      <xsd:pattern value="\d{3}-[A-Z]{2}"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:schema>
```

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