Oracle® Database

JDBC Developer's Guide and Reference

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This book describes how to use the Oracle JDBC drivers to develop powerful Java database applications.

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Oracle Database JDBC Developer's Guide and Reference, 10*g* Release 1 (10.1)

Part No. B10979-01

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Preface

This preface introduces you to the *Oracle Database JDBC Developer's Guide and Reference* discussing the intended audience, structure, and conventions of this document. A list of related Oracle documents is also provided.

This Preface contains these topics:

Intended Audience

Oracle Database JDBC Developer's Guide and Reference is intended for developers of JDBC-based applications and applets. This book can be read by anyone with an interest in JDBC programming, but assumes at least some prior knowledge of the following:

- Java
- Oracle PL/SQL
- Oracle databases

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Structure

This document contains the following chapters and appendices:

- Chapter 1, "Overview"—Provides an overview of the Oracle implementation of JDBC and the Oracle JDBC driver architecture.
- Chapter 2, "Getting Started"—Introduces the Oracle JDBC drivers and some scenarios of how you can use them. This chapter also guides you through the basics of testing your installation and configuration.
- Chapter 3, "Datasources and URLs"—Discusses connecting applications to databases using JDBC datasources, as well as the URLs that describe databases.
- Chapter 4, "Basic Features"—Covers the basic steps in creating any JDBC application. It also discusses additional basic features of Java and JDBC supported by the Oracle JDBC drivers.
- Chapter 5, "JDBC Standards Support"—Presents an overview of JDBC 2.0 and 3.0 features and describes how these features are supported different versions of the JDK.
- Chapter 6, "Statement Caching"—Describes Oracle extension statements for caching.
- Chapter 7, "Implicit Connection Caching"—Describes the new implicit connection cache.
- Chapter 8, "Fast Connection Failover"—Describes the fast connection failover mechanism, which depends on the implicit connection cache.
- Chapter 9, "Distributed Transactions"—Covers distributed transactions, otherwise known as global transactions, and standard XA functionality. (Distributed transactions are sets of transactions, often to multiple databases, that have to be committed in a coordinated manner.)
- Chapter 10, "Oracle Extensions"—Provides an overview of the JDBC extension classes supplied by Oracle.
- Chapter 11, "Accessing and Manipulating Oracle Data"—Describes data access using the Oracle datatype formats rather than Java formats.
- Chapter 12, "Globalization Support"—Describes support for multi-byte character sets and other globalization issues.
- Chapter 13, "Working with Oracle Object Types"—Explains how to map Oracle object types to Java classes by using either standard JDBC or Oracle extensions.
- Chapter 14, "Working with LOBs and BFILEs"—Covers the Oracle extensions to the JDBC standard that let you access and manipulate LOBs and LOB data.

- Chapter 15, "Using Oracle Object References"—Describes the Oracle extensions to standard JDBC that let you access and manipulate object references.
- Chapter 16, "Working with Oracle Collections"—Discusses the Oracle extensions to standard JDBC that let you access and manipulate arrays and their data.
- Chapter 17, "Result Set Enhancements"—This chapter discusses JDBC 2.0 result set enhancements such as scrollable result sets and updatable result sets.
- Chapter 18, "Row Set"—Describes JDBC cached and web row sets.
- Chapter 19, "JDBC OCI Extensions"—Describes extensions specific to the OCI driver.
- Chapter 20, "OCI Instant Client"—Describes OCI support for Instant Client.
- Chapter 21, "End-To-End Metrics Support"—Describes JDBC support for end-to-end database metrics.
- Chapter 22, "Performance Extensions"—Describes Oracle extensions to the JDBC standard that enhance the performance of your applications.
- Chapter 23, "Advanced Topics"—Describes advanced JDBC topics such as globalization support, working with applets, the server-side driver, and embedded SQL92 syntax.
- Chapter 24, "Reference Information"—Contains detailed JDBC reference information.
- Chapter 25, "Proxy Authentication"—Describes middle-tier authentication using proxies.
- Chapter 26, "Coding Tips and Troubleshooting"—Includes coding tips and general guidelines for troubleshooting your JDBC applications.
- Appendix A, "JDBC Error Messages"—Lists JDBC error messages and the corresponding `ORA` error numbers.

Related Documents

Also available from the Oracle Java Platform group

- *Oracle Database Java Developer's Guide*

  This book introduces the basic concepts of Java and provides general information about server-side configuration and functionality. Information that pertains to the Oracle Java platform as a whole, rather than to a particular product (such as JDBC) is in this book. This book also discusses Java stored procedures, which were formerly discussed in a standalone book.

- *Oracle Database JPublisher User's Guide*

  This book describes how to use the Oracle JPublisher utility to translate object types and other user-defined types to Java classes. If you are developing JDBC applications that use object types, VARRAY types, nested table types, or object reference types, then JPublisher can generate custom Java classes to map to them.

The following OC4J documents, for Oracle Application Server releases, are also available from the Oracle Java Platform group:

- *Oracle Application Server Containers for J2EE User's Guide*

This book provides some overview and general information for OC4J; primer chapters for servlets, JSP pages, and EJBs; and general configuration and deployment instructions.

- *Oracle Application Server Containers for J2EE Support for JavaServer Pages Developer's Guide*

  This book provides information for JSP developers who want to run their pages in OC4J. It includes a general overview of JSP standards and programming considerations, as well as discussion of Oracle value-added features and steps for getting started in the OC4J environment.

- *Oracle Application Server Containers for J2EE JSP Tag Libraries and Utilities Reference*

  This book provides conceptual information and detailed syntax and usage information for tag libraries, JavaBeans, and other Java utilities provided with OC4J.

- *Oracle Application Server Containers for J2EE Servlet Developer's Guide*

  This book provides information for servlet developers regarding use of servlets and the servlet container in OC4J. It also documents relevant OC4J configuration files.

- *Oracle Application Server Containers for J2EE Services Guide*

  This book provides information about basic Java services supplied with OC4J, such as JTA, JNDI, and the Oracle Application Server Java Object Cache.

- *Oracle Application Server Containers for J2EE Enterprise JavaBeans Developer's Guide*

  This book provides information about the EJB implementation and EJB container in OC4J.

The following documents are from the Oracle Server Technologies group:

- *Oracle Database Application Developer's Guide - Fundamentals*
- *PL/SQL Packages and Types Reference*
- *PL/SQL User's Guide and Reference*
- *Oracle Database SQL Reference*
- *Oracle Net Services Administrator's Guide*
- *Oracle Advanced Security Administrator's Guide*
- *Oracle Database Reference*
- *Oracle Database Error Messages*

The following documents from the Oracle Application Server group may also be of some interest:

- *Oracle Application Server 10g Administrator's Guide*
- *Oracle Enterprise Manager Administrator's Guide*
- *Oracle HTTP Server Administrator's Guide*
- *Oracle Application Server 10g Performance Guide*
- *Oracle Application Server 10g Globalization Guide*
- *Oracle Application Server Web Cache Administrator's Guide*
- *Oracle Application Server 10g Upgrading to 10g (9.0.4)*

The following are available from the JDeveloper group:

- Oracle JDeveloper online help
- Oracle JDeveloper documentation on the Oracle Technology Network:

  `http://otn.oracle.com/products/jdev/content.html`

Printed documentation is available for sale in the Oracle Store at

`http://oraclestore.oracle.com/`

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://otn.oracle.com/membership/`

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

`http://otn.oracle.com/documentation/`

The following resources are available from Sun Microsystems:

- Web site for Java Server Pages, including the latest specifications:

  `http://java.sun.com/products/jsp/index.html`
- Web site for Java Servlet technology, including the latest specifications:

  `http://java.sun.com/products/servlet/index.html`
- `jsp-interest` discussion group for Java Server Pages

  To subscribe, send an e-mail to `listserv@java.sun.com` with the following line in the body of the message:

  `subscribe jsp-interest` *`yourlastname yourfirstname`*

  It is recommended, however, that you request only the daily digest of the posted e-mails. To do this add the following line to the message body as well:

  ```
  set jsp-interest digest
  ```

Conventions

This section describes the conventions used in the text and code examples of this documentation set. It describes:

- Conventions in Text
- Conventions in Code Examples
- Conventions for Windows Operating Systems

Conventions in Text

We use various conventions in text to help you more quickly identify special terms. The following table describes those conventions and provides examples of their use.

Convention	Meaning	Example
Bold	Bold typeface indicates terms that are defined in the text or terms that appear in a glossary, or both.	When you specify this clause, you create an **index-organized table**.
Italics	Italic typeface indicates book titles or emphasis.	*Oracle Database Concepts* Ensure that the recovery catalog and target database do *not* reside on the same disk.
`UPPERCASE monospace (fixed-width) font`	Uppercase monospace typeface indicates elements supplied by the system. Such elements include parameters, privileges, datatypes, RMAN keywords, SQL keywords, SQL*Plus or utility commands, packages and methods, as well as system-supplied column names, database objects and structures, usernames, and roles.	You can specify this clause only for a `NUMBER` column. You can back up the database by using the `BACKUP` command. Query the `TABLE_NAME` column in the `USER_TABLES` data dictionary view. Use the `DBMS_STATS.GENERATE_STATS` procedure.
`lowercase monospace (fixed-width) font`	Lowercase monospace typeface indicates executables, filenames, directory names, and sample user-supplied elements. Such elements include computer and database names, net service names, and connect identifiers, as well as user-supplied database objects and structures, column names, packages and classes, usernames and roles, program units, and parameter values. **Note:** Some programmatic elements use a mixture of UPPERCASE and lowercase. Enter these elements as shown.	Enter `sqlplus` to start SQL*Plus. The password is specified in the `orapwd` file. Back up the datafiles and control files in the `/disk1/oracle/dbs` directory. The `department_id`, `department_name`, and `location_id` columns are in the `hr.departments` table. Set the `QUERY_REWRITE_ENABLED` initialization parameter to `true`. Connect as `oe` user. The `JRepUtil` class implements these methods.
`lowercase italic monospace (fixed-width) font`	Lowercase italic monospace font represents placeholders or variables.	You can specify the *`parallel_clause`*. Run *`old_release`*`.SQL` where *`old_release`* refers to the release you installed prior to upgrading.

Conventions in Code Examples

Code examples illustrate Java, SQL, and command-line statements. Examples are displayed in a monospace (fixed-width) font and separated from normal text as shown in this example:

```
SELECT username FROM dba_users WHERE username = 'MIGRATE';
```

The following table describes typographic conventions used in code examples and provides examples of their use.

Convention	Meaning	Example
`[ ]`	Brackets enclose one or more optional items. Do not enter the brackets.	`DECIMAL (digits [ , precision ])`
`{ }`	Braces enclose two or more items, one of which is required. Do not enter the braces.	`{ENABLE | DISABLE}`
`|`	A vertical bar represents a choice of two or more options within brackets or braces. Enter one of the options. Do not enter the vertical bar.	`{ENABLE | DISABLE}` `[COMPRESS | NOCOMPRESS]`

`...`	Horizontal ellipsis points indicate either:
	■ That we have omitted parts of the code that are not directly related to the example
	■ That you can repeat a portion of the code
		`CREATE TABLE ... AS subquery;`
		
		`SELECT col1, col2, ... , coln FROM employees;`

. . .	Vertical ellipsis points indicate that we have omitted several lines of code not directly related to the example.	`SQL> SELECT NAME FROM V$DATAFILE;`
		`NAME`
		`----------`
		`/fsl/dbs/tbs_01.dbf`
		`/fs1/dbs/tbs_02.dbf`
		`.`
		`.`
		`.`
		`/fsl/dbs/tbs_09.dbf`
		`9 rows selected.`

Other notation	You must enter symbols other than brackets, braces, vertical bars, and ellipsis points as shown.	`acctbal NUMBER(11,2);` `acct CONSTANT NUMBER(4) := 3;`
Italics	Italicized text indicates placeholders or variables for which you must supply particular values.	`CONNECT SYSTEM/system_password` `DB_NAME = database_name`

`UPPERCASE`	Uppercase typeface indicates elements supplied by the system. We show these terms in uppercase in order to distinguish them from terms you define. Unless terms appear in brackets, enter them in the order and with the spelling shown. However, because these terms are not case sensitive, you can enter them in lowercase.	`SELECT last_name, employee_id FROM employees;`
		`SELECT * FROM USER_TABLES;`
		`DROP TABLE hr.employees;`

`lowercase`	Lowercase typeface indicates programmatic elements that you supply. For example, lowercase indicates names of tables, columns, or files.
	Note: Some programmatic elements use a mixture of UPPERCASE and lowercase. Enter these elements as shown.
		`SELECT last_name, employee_id FROM employees;`
		`sqlplus hr/hr`
		`CREATE USER mjones IDENTIFIED BY ty3MU9;`

Conventions for Windows Operating Systems

The following table describes conventions for Windows operating systems and provides examples of their use.

Convention	Meaning	Example
Choose Start >	How to start a program.	To start the Database Configuration Assistant, choose Start > Programs > Oracle - *HOME_NAME* > Configuration and Migration Tools > Database Configuration Assistant.
File and directory names	File and directory names are not case sensitive. The following special characters are not allowed: left angle bracket (<), right angle bracket (>), colon (:), double quotation marks ("), slash (/), pipe (|), and dash (-). The special character backslash (\) is treated as an element separator, even when it appears in quotes. If the file name begins with \\, then Windows assumes it uses the Universal Naming Convention.	`c:\winnt"\"system32 is the same as C:\WINNT\SYSTEM32`
`C:\>`	Represents the Windows command prompt of the current hard disk drive. The escape character in a command prompt is the caret (^). Your prompt reflects the subdirectory in which you are working. Referred to as the *command prompt* in this manual.	`C:\oracle\oradata>`
Special characters	The backslash (\) special character is sometimes required as an escape character for the double quotation mark (") special character at the Windows command prompt. Parentheses and the single quotation mark (') do not require an escape character. Refer to your Windows operating system documentation for more information on escape and special characters.	`C:\>exp scott/tiger TABLES=emp QUERY=\"WHERE job='SALESMAN' and sal<1600\"` `C:\>imp SYSTEM/`*`password`*` FROMUSER=scott TABLES=(emp, dept)`
HOME_NAME	Represents the Oracle home name. The home name can be up to 16 alphanumeric characters. The only special character allowed in the home name is the underscore.	`C:\> net start Oracle`*`HOME_NAME`*`TNSListener`

Convention	Meaning	Example
ORACLE_HOME and *ORACLE_BASE*	In releases prior to Oracle8*i* release 8.1.3, when you installed Oracle components, all subdirectories were located under a top level *ORACLE_HOME* directory that by default used one of the following names: ▪ `C:\orant` for Windows NT ▪ `C:\orawin98` for Windows 98 This release complies with Optimal Flexible Architecture (OFA) guidelines. All subdirectories are not under a top level *ORACLE_HOME* directory. There is a top level directory called *ORACLE_BASE* that by default is `C:\oracle`. If you install the latest Oracle release on a computer with no other Oracle software installed, then the default setting for the first Oracle home directory is `C:\oracle\ora`*nn*, where *nn* is the latest release number. The Oracle home directory is located directly under *ORACLE_BASE*. All directory path examples in this guide follow OFA conventions. Refer to *Oracle Database Platform Guide for Windows* for additional information about OFA compliances and for information about installing Oracle products in non-OFA compliant directories.	Go to the *ORACLE_BASE*`\`*ORACLE_HOME*`\rdbms\admin` directory.

1

Overview

This chapter provides an overview of the Oracle implementation of JDBC, covering the following topics:

What is JDBC?

JDBC (Java Database Connectivity) is a standard Java interface for connecting from Java to relational databases. The JDBC standard was defined by Sun Microsystems, allowing individual providers to implement and extend the standard with their own JDBC drivers.

JDBC is based on the X/Open SQL Call Level Interface and complies with the SQL92 Entry Level standard.

In addition to supporting the standard JDBC API, Oracle drivers have extensions to support Oracle-specific datatypes and to enhance performance.

Overview of the Oracle JDBC Drivers

This section introduces the Oracle JDBC drivers, their basic architecture, and some scenarios for their use. This information describes the core functionality of all JDBC drivers. However, there is special functionality for the OCI driver, which is described Chapter 19, "JDBC OCI Extensions".

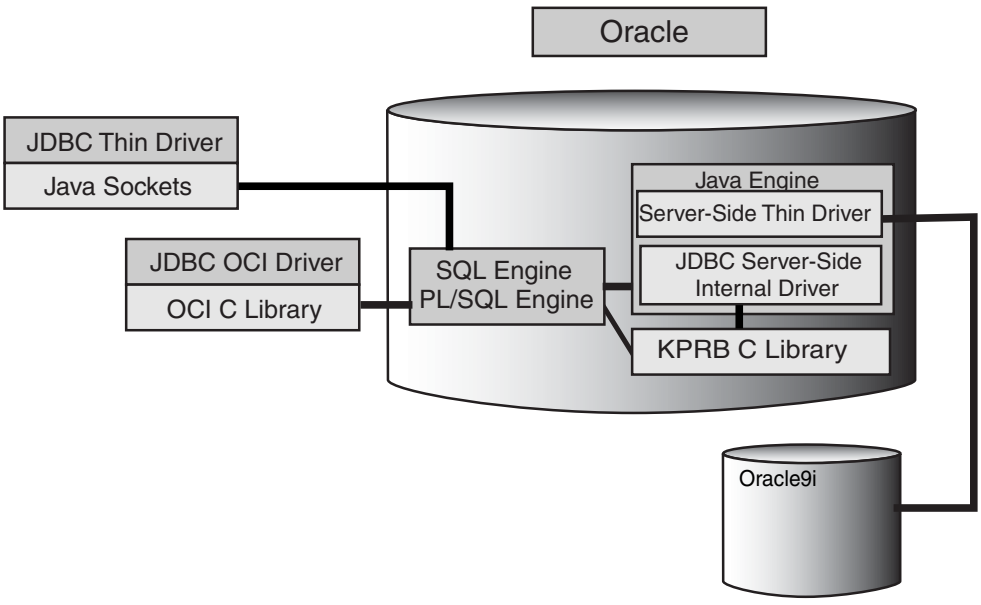
Oracle provides the following JDBC drivers:

- **Thin driver**, a 100% Java driver for client-side use without an Oracle installation; can be used with applets and applications
- **OCI driver** for client-side use with an Oracle client installation; can be used with applications
- **server-side Thin driver**, which is functionally the same as the client-side Thin driver, but is for code that runs inside an Oracle server and needs to access another session either on the same server or a remote server, including middle-tier scenarios
- **server-side internal driver** for code that runs inside an Oracle server and accesses the same session (that is, inside the Oracle session that it must access)

Figure 1–1 illustrates the driver-database architecture for the JDBC Thin, OCI, and server-side internal drivers.

The rest of this section describes common features of the Oracle drivers and then discusses each one individually, concluding with a discussion of some of the considerations in choosing the appropriate driver for your application.

Figure 1–1 Driver-Database Architecture



Common Features of Oracle JDBC Drivers

The server-side and client-side Oracle JDBC drivers provide the same basic functionality.

The Thin and OCI drivers support the following JDKs: 1.2.x, 1.3.x and 1.4.x. The server side Thin driver and server side internal driver support JDK 1.4.1. All the JDBC drivers support the following standards and features:

- same syntax and APIs
- same Oracle extensions
- full support for multi-threaded applications

Oracle JDBC drivers implement standard Sun Microsystems `java.sql` interfaces. Through the `oracle.jdbc` package, you can access the Oracle features in addition to the Sun features.

JDBC Thin Driver

The Oracle JDBC Thin driver is a 100% pure Java, Type IV driver that can be used in applications and applets. Because it is written entirely in Java, this driver is platform-independent. It does not require any additional Oracle software on the client side. The Thin driver communicates with the server using TTC, a protocol developed by Oracle to access the Oracle Relational Database Management System (RDBMS).

The JDBC Thin driver allows a direct connection to the database by providing an implementation of SQL*Net and TTC (the wire protocol used by OCI) on top of Java sockets. Both of these protocols are lightweight implementation versions of their counterparts on the server. The Thin driver runs over TCP/IP only.

The driver supports only the TCP/IP protocol and requires a TNS listener on the TCP/IP sockets from the database server.

Note: When the JDBC Thin driver is used with an applet, the client browser must have the capability to support Java sockets.

For applets, the Thin driver can be downloaded into a browser along with the Java applet being run. The HTTP protocol is stateless, but the Thin driver is not. The initial HTTP request to download the applet and the Thin driver is stateless. Once the Thin driver establishes the database connection, the communication between the browser and the database is stateful.

Using the Thin driver inside an Oracle server is considered separately, under "JDBC Server-Side Thin Driver" below.

JDBC OCI Driver

The JDBC OCI driver is a Type II driver for use with client-server Java applications. This driver requires an Oracle client installation, and therefore is Oracle platform-specific.

The JDBC OCI driver provides OCI connection pooling functionality, which can either be part of the JDBC client or a JDBC stored procedure. OCI driver connection pooling requires fewer physical connections than standard connection pooling. For a complete description of OCI driver connection pooling, see "OCI Driver Connection Pooling" on page 19-1.

The OCI driver supports all installed Oracle Net adapters, including IPC, named pipes, TCP/IP, and IPX/SPX.

The OCI driver, written in a combination of Java and C, converts JDBC invocations to calls to the Oracle Call Interface (OCI), using native methods to call C-entry points. These calls are then sent over Oracle Net to the Oracle database server. The OCI driver communicates with the server using the Oracle-developed TTC protocol.

The OCI driver uses the OCI libraries, C-entry points, Oracle Net, CORE libraries, and other necessary files on the client machine on which it is installed. At this release, the OCI driver supports Instant Client deployment; see Chapter 20, "OCI Instant Client" for details.

The Oracle Call Interface (OCI) is an application programming interface (API) that allows you to create applications that use the native procedures or function calls of a third-generation language to access an Oracle database server and control all phases of SQL statement execution.

The JDBC OCI driver has the following functionality:

- Uses OCI
- Connection Pooling
- OCI optimized fetch
- Prefetching
- Client-side object cache
- Transparent Application Failover (TAF)
- Middle-tier authentication
- Advanced security

JDBC Server-Side Thin Driver

The Oracle JDBC server-side Thin driver offers the same functionality as the client-side Thin driver, but runs inside an Oracle database and accesses a remote database or a different session on the same database.

This is especially useful in two situations:

- to access a remote Oracle server from an Oracle server acting as a middle tier
- more generally, to access one Oracle server from inside another, such as from a Java stored procedure

There is no difference in your code between using the Thin driver from a client application or from inside a server.

> **Note:** Statement `cancel()` and `setQueryTimeout()` methods are not supported by the server-side Thin driver.

About Permission for the Server-Side Thin Driver

The thin driver opens a socket to use for its connection. Because the Oracle server is enforcing the Java security model, this means that a check is performed for a `SocketPermission` object.

To use the JDBC server-side Thin driver, the connecting user must be granted with the appropriate permission. This is an example of how the permission can be granted for user SCOTT:

```
create role jdbcthin;
call dbms_java.grant_permission('JDBCTHIN',
'java.net.SocketPermission',
'*', 'connect' );
grant jdbcthin to scott;
```

Note that JDBCTHIN in the grant_permission call must be in upper case. The '*' is a pattern. It is possible to limit the permission to allow connecting to specific machines or ports. See the Javadoc for complete details on the java.net.SocketPermission class. Also, refer to the *Oracle Database Java Developer's Guide* for further discussion of Java security inside the Oracle server.

JDBC Server-Side Internal Driver

The Oracle JDBC server-side internal driver supports any Java code that runs inside an Oracle database, such as in a Java stored procedures or Enterprise JavaBean, and must access the same database. This driver allows the Java virtual machine (JVM) to communicate directly with the SQL engine.

The server-side internal driver, the JVM, the database, and the SQL engine all run within the same address space, so the issue of network round trips is irrelevant. The programs access the SQL engine by using function calls.

The server-side internal driver is fully consistent with the client-side drivers and supports the same features and extensions. For more information on the server-side internal driver, see "JDBC in the Server: the Server-Side Internal Driver" on page 23-15.

Notes:
- The server-side internal driver supports only JDK 1.4.1.
- The server-side internal driver does not support the Statement cancel() and setQueryTimeout() methods.

Choosing the Appropriate Driver

Consider the following when choosing a JDBC driver to use for your application or applet:

- In general, unless you need OCI-specific features such as support for non-TCP/IP networks, use the Thin driver. At 10*g* Release 1 (10.1), the Thin driver has excellent performance and functionality.
- If you want maximum portability and performance, use the JDBC Thin driver. You can connect to an Oracle server from either an application or an applet using the JDBC Thin driver.
- If you want to use LDAP over SSL, use the Thin driver. See Table 3–3, " Supported Database Specifiers" for details.
- If you are writing a client application for an Oracle client environment and need OCI-driver-specific features, such as support for non-TCP/IP networks, then choose the JDBC OCI driver.
- If you are writing an applet, you must use the Thin driver.
- For code that runs in an Oracle server acting as a middle tier, use the server-side Thin driver.

- If your code will run inside the target Oracle server, then use the JDBC server-side internal driver to access that server. (You can also access remote servers using the server-side Thin driver.)

Overview of Application and Applet Functionality

This section compares and contrasts the basic functionality of JDBC applications and applets, and introduces Oracle extensions that can be used by application and applet programmers.

Applet Basics

You can use only the Oracle JDBC Thin driver for an applet.

For more about applets and a discussion of relevant firewall, browser, and security issues, see "JDBC in Applets" on page 23-7.

Applets and Security

Without special preparations, an applet can open network connections only to the host machine from which it was downloaded. Therefore, an applet can connect to databases only on the originating machine. If you want to connect to a database running on a different machine, you have two options:

- Use the Oracle Connection Manager on the host machine. The applet can connect to Connection Manager, which in turn connects to a database on another machine.
- Use signed applets, which can request socket connection privileges to other machines.

Both of these topics are described in greater detail in "Connecting to the Database through the Applet" on page 23-7.

Your applet can take advantage of the data encryption and integrity checksum features of the Oracle Advanced Security option. See "JDBC Client-Side Security Features" on page 23-1.

Applets and Firewalls

An applet can connect to a database through a firewall. See "Using Applets with Firewalls" on page 23-11 for more information on configuring the firewall and on writing connect strings for the applet.

Packaging and Deploying Applets

To package and deploy an applet, you must place the JDBC Thin driver classes and the applet classes in the same zip file. This is described in detail in "Packaging Applets" on page 23-13.

Oracle Extensions

A number of Oracle extensions are available to Oracle JDBC application and applet programmers, in the following categories:

- type extensions (such as ROWIDs and REF CURSOR types)
- wrapper classes for SQL types (the `oracle.sql` package)
- support for custom Java classes to map to user-defined types
- extended LOB support
- extended connection, statement, and result set functionality
- performance enhancements

See Chapter 10, "Oracle Extensions" for an overview of type extensions and extended functionality, and succeeding chapters for further detail. See Chapter 22, "Performance Extensions" regarding Oracle performance enhancements.

Server-Side Basics

By using the Oracle JDBC server-side internal driver, code that runs in an Oracle database, such as in Java stored procedures or Enterprise JavaBeans, can access the database in which it runs.

For a complete discussion of the server-side driver, see "JDBC in the Server: the Server-Side Internal Driver" on page 23-15.

Session and Transaction Context

The server-side internal driver operates within a default session and default transaction context. For more information on default session and transaction context for the server-side driver, see "Session and Transaction Context for the Server-Side Internal Driver" on page 23-18.

Connecting to the Database

The server-side internal driver uses a default connection to the database. You connect to the database with the `OracleDataSource.getconnection()` method. For more information on connecting to the database with the server-side driver, see "Connecting to the Database with the Server-Side Internal Driver" on page 23-15.

Environments and Support

This section provides a brief discussion of platform, environment, and support features of the Oracle JDBC drivers. The following topics are discussed:

- Supported JDK and JDBC Versions
- JNI and Java Environments
- JDBC and IDEs

Supported JDK and JDBC Versions

Starting at 10*g* Release 1 (10.1), all the JDBC drivers are compatible with JDK 1.2.x and higher; the `classes111.zip`, `classes111.jar`, `classes111_g.zip`, `classes111_g.jar`, and `nls_charset11.zip` files are no longer provided.

Backward Compatibility

The Oracle JDBC drivers are certified to work with currently-supported versions of the database. For example:

- The 10*g* Release 1 (10.1) JDBC drivers are certified to work with 10.0.x, 9.2.x, 9.0.1.x, and 8.1.7.x database releases.
- The 9.2 Oracle JDBC drivers are certified to work with 9.2.x, 9.0.1.x, and 8.1.7 database releases.
- The 9.2 Oracle JDBC drivers are not certified to work with older, unsupported database releases, such as 8.0.x and 7.x.

Forward Compatibility

Existing supported JDBC drivers (Oracle8i 8.1.7.4 and Oracle9i JDBC drivers) are certified to work against Oracle Database 10g; known limitations will be documented.

Note: You can find a complete up-to-date list of supported databases at `http://metalink.oracle.com`, Note 203849.1.

JNI and Java Environments

The Oracle JDBC OCI driver uses the standard JNI (Java Native Interface) to call Oracle OCI C libraries. You can use the OCI driver with Java virtual machines other than that of Sun Microsystems—in particular, with Microsoft and IBM JVMs.

JDBC and IDEs

The Oracle JDeveloper Suite provides developers with a single, integrated set of products to build, debug, and deploy component-based database applications for the Oracle Internet platform. The Oracle JDeveloper environment contains integrated support for JDBC, including the 100% pure JDBC Thin driver and the native OCI drivers. The database component of Oracle JDeveloper uses the JDBC drivers to manage the connection between the application running on the client and the server. See your Oracle JDeveloper documentation for more information.

Changes At This Release

10*g* Release 1 (10.1) of Oracle JDBC provides many enhancements. This section gives an overview of those enhancements. It is divided into the following sections:

New Features

- Support for the Oracle datatypes `TIMESTAMP`, `TIMESTAMP WITH TIME ZONE`, and `TIMESTAMP WITH LOCAL TIME ZONE`. See Table 24–1, " Valid SQL Datatype-Java Class Mappings" on page 24-1.
- **A new statement cache API**; the old API is now deprecated. See Chapter 6, "Statement Caching".

- **Improved Performance in the JDBC Drivers**. The JDBC Thin, OCI, and server-side internal drivers have been completely restructured to improve performance.
- **Compliance with the JDBC3.0 and J2EE 1.3 standards.** See Chapter 5, "JDBC Standards Support".
- **Support for Oracle 10g database features, including support for EEE double, VARRAY enhancements, INTERVAL-DAY-TO-SECOND, LONG-to-LOB conversion, UNLIMITED LSIZE LOBs and native IEEE float**.
- **Improved Connection Caching.** The Implicit Connection Cache is an improved JDBC3.0-compliant connection cache implementation for `DataSource`. Java and J2EE applications now benefit from transparent access to the cache, support for multiple users, and the ability to request connections based on user-defined profiles. See Chapter 7, "Implicit Connection Caching".
- **Updated Globalization Support.** A new globalization file, `orai18n.jar`, supersedes the old `nls_charset` files. See Chapter 12, "Globalization Support".
- **Named SQL Parameter Support**. `PreparedStatement` and `CallableStatement` now support referring to SQL parameters by name as well as by numeric position. See "Interface oracle.jdbc.OracleCallableStatement" on page 10-15 and "Interface oracle.jdbc.OraclePreparedStatement" on page 10-14.
- **Two New Encryption Algorithms**. The JDBC Thin driver now supports `3DES112` and `3DES168` as values for the connection property `SQLNET.ENCRYPTION_TYPES_CLIENT` in the JDBC Thin driver.
- **Thin Driver PL/SQL Index Table**. You can now send and receive PL/SQL tables using the Thin driver. For example, you can exchange Java collections with PL/SQL collections.
- **Instant Client For JDBC-OCI Driver**. The JDBC drivers now support Easy Instant Client for OCI. See Chapter 20, "OCI Instant Client" for details.
- **String Length Increased in LONG Columns.** `OraclePreparedStatement.setString()` now accepts `Strings` up to 32766 characters long and can insert these `Strings` into `LONG` columns. If you specify a longer string, an `ORA-17157` error is thrown.
- **Two new JAR files,** `ojdbc14dms.jar` and `ojdbc14dms_g.jar`, **have been added to the release.** If your application uses JDBC1.4 features and DMS, you must add one of these files to your `CLASSPATH`. Use `ojdbc14dms.jar` if you use both JDK1.4 and DMS; use `jdbc14dms_g.jar` if you use JDK1.4 and DMS and need debugging features.

  Note: These two JAR files are only available as part of Oracle Application Server 10*g*.

- **ojdbc14_g.jar and ojdbc14dms_g.jar now use java.util.logging instead of OracleLog.**
- **Fast connection failover.** This High Availability feature supports rapid detection and restarting of failed connections to a RAC database in the JDBC connection cache. When this feature is enabled, JDBC subscribes to RAC event notifications for instance and host failures. Upon receiving these events, JDBC processes the connection cache to remove invalid connections and replace them as necessary. See Chapter 8, "Fast Connection Failover".

- **End-to-end metric support**. JDBC now supports the `Action`, `ClientId`, `ExecutionContextId`, and `Module` metrics in DMS monitoring. See Chapter 21, "End-To-End Metrics Support".
- **Full support for binary_float and binary_double as JSP parameters and in the server-side internal driver**.
- **Support for proxy connections to the database**. The `oracle.jdbc.OracleConnection` class now supports the methods `openProxySession()`, to create a proxy session, and `isProxySession()`, which returns `true` if the current session is a proxy session, `false` otherwise.
- **Native XA support**. The Thin driver has a high-performance native XA implementation, which is the implementation used by default. `Oracle.jdbc.xa.OracleXADatasource` has the methods `setNativeXA()` and `getNativeXA()`. Call `setNativeXA(true)` to use the native XA implementation (this is the default); call `setNativeXA(false)` to use the older, generic XA implementation. The `getNativeXA()` method returns `true` if the native implementation is in use, `false` otherwise.
- **Support for checking PL/SQL compiler warnings**. The OCI and Thin drivers now support fetching and checking PL/SQL compiler warnings, enabling and disabling these warnings, and specifying which categories of warnings to receive.
- **The class oracle.jdbc.OracleConnection has a new method, setPlsqlWarnings()**, which allows users to enable and disable all or some categories of warnings. This method takes a `String` argument which specifies warning settings. When there are PL/SQL compiler warnings, JDBC automatically generates `SQLWarning` exceptions; if a `SQLWarning` has the error code 24439, there are compiler warnings available to check. See the Javadoc for further information.
- **Server-side Internal Driver support for JDBC3.0.** The server-side internal driver provides JDBC 3.0 support similar to that provided by `ojdbc14.jar`.
- **Support for the JDBC3.0 class WebRowSet**. See Chapter 18, "Row Set".

Deprecated Features

The class OracleConnectionCacheImpl. The new Implicit Connection Cache replaces this class. You should migrate your application to the new connection cache as quickly as possible, because the new implementation is more powerful and easier to use.

Desupported Features

- **ZIP files**. All class libraries are now supplied in JAR format only.
- **Support for JDK1.1**. 10*g* Release 1 (10.1) of JDBC does not support JDK1.1. The files `classes111.zip`, `classes111.jar`, `classes111_g.zip`, and `classes111_g.jar` are not included in this release.
- The multi-language globalization files `nls_charset11.zip`, `nls_charset11.jar`, `nls_charset12.zip`, and `nls_charset12.jar`. To support globalization, add `orai18n.jar` to your `CLASSPATH`. See Chapter 12, "Globalization Support".
- **OracleLog is deprecated when using ojdbc14.jar.** If your application uses `OracleLog` and `ojdbc14_g.jar`, you should be aware of the following issues:
  - `OracleLog.setTraceEnable()` is supported and must be called to turn on tracing.
  - `OracleLog.setLogStream()` is supported, but `OracleLog.setLogWriter()` is not supported.
  - No other `OracleLog()` methods are supported.

  We recommend that you use the standard Java logging facilities in `java.util.logging`.
- **NLS_LANG dependency removal**. The `NLS_LANG` variable is now completely desupported; setting `NLS_LANG` now has no effect.

Interface Changes

This release contains the following changes to the interfaces of existing methods:

- The interface for `OracleStatement.defineColumnType()` has changed; see "Defining Column Types" on page 22-17.
- Handling of international character sets has changed. See Chapter 12, "Globalization Support" for details.
- `CallableStatement` instances that invoke PL/SQL procedures must register all `out` parameters using `CallableStatement.registerOutParameter()`. If a `CallableStatement` invokes a procedure without registering its `out` parameters, a `NullPointerException` may be thrown.
- As of this release, you must supply the `size` parameter when invoking `OracleStatement.defineColumnType()` on a `CHAR` or `VARCHAR` column. In previous releases, the `size` parameter was interpreted in bytes; it is now interpreted in Java `chars`. When using the Thin driver, it is best to avoid using `defineColumnType()`. No benefit is derived from using this method; it can cause problems if the arguments are not optimal. If `defineColumnType()` is not used, the Thin driver behaves exactly as if the optimal arguments were used.

> **Note:** The `defineColumnTypeBytes()` and `defineColumnTypeChars()` methods now also interpret `size` in Java `chars`, and are deprecated.

2

Getting Started

This chapter begins by discussing compatibilities between Oracle JDBC driver versions, database versions, and JDK versions. It then guides you through the basics of testing your installation and configuration, and running a simple application. The following topics are discussed:

- Compatibilities for Oracle JDBC Drivers
- Verifying a JDBC Client Installation

Compatibilities for Oracle JDBC Drivers

This section discusses general JDBC version compatibility issues.

Backward Compatibility

The JDBC drivers are certified to work with the currently supported versions of the database. (You can find a complete up-to-date list of supported databases at `http://metalink.oracle.com`, Note 203849.1.) For example, the 10*g* Release 1 (10.1) JDBC Thin drivers are certified to work with the 9.2.x, 9.0.1.x, and 8.1.7 database releases. The 10*g* Release 1 (10.1) JDBC thin drivers are not certified to work with older, unsupported database releases, such as 8.0.x and 7.x.

Forward Compatibility

Existing supported JDBC drivers (Oracle8i 8.1.7.4 and Oracle9i JDBC drivers) are certified to work against Oracle Database 10g; known limitations will be documented.

Notes: ■Starting with 10*g* Release 1 (10.1), the Oracle JDBC drivers no longer support JDK 1.1.x or earlier versions.

- You can find a complete, up-to-date list of supported databases at `http://metalink.oracle.com`, Note 203849.

Verifying a JDBC Client Installation

This section covers the following topics:

- Check Installed Directories and Files
- Check the Environment Variables
- Make Sure You Can Compile and Run Java
- Determine the Version of the JDBC Driver
- Testing JDBC and the Database Connection: JdbcCheckup

Installation of an Oracle JDBC driver is platform-specific. Follow the installation instructions for the driver you want to install in your platform-specific documentation.

This section describes the steps of verifying an Oracle client installation of the JDBC drivers. It assumes that you have already installed the driver of your choice.

If you have installed the JDBC Thin driver, no further installation on the client machine is necessary (the JDBC Thin driver requires a TCP/IP listener to be running on the database machine).

If you have installed the JDBC OCI driver, you must also install the Oracle client software. This includes Oracle Net and the OCI libraries.

Check Installed Directories and Files

This section assumes that you have already installed the Sun Microsystems *Java Developer's Kit (JDK)* on your system (although other forms of Java are also supported). Oracle offers JDBC drivers compatible with the JDK1.4, 1.3.x, and 1.2.x versions.

Installing the Oracle Java products creates, among other things, an *ORACLE_HOME*`/jdbc` directory and an *ORACLE_HOME* `/jlib` directory.

The *ORACLE_HOME*`/jdbc` directory contains these subdirectories and files:

- `demo`: Contains a compressed file, either (Windows) `demo.zip` or (UNIX) `demo.tar`. in the demo directory. When you unpack the appropriate file, it creates a `samples` subdirectory and a `Samples-Readme.txt` file. The `samples` subdirectory contains sample programs, including examples of how to use SQL92 and Oracle SQL syntax, PL/SQL blocks, streams, user-defined types, additional Oracle type extensions, and Oracle performance extensions.
- `doc`: Contains a `javadoc.zip` file which is the Oracle JDBC API documentation.
- `lib`: The `lib` directory contains these required Java classes:
  - `orai18n.jar`: Contains classes for globalization and supporting multibyte character sets

  - `classes12.jar` and `classes12_g.jar` Contain the JDBC driver classes for use with JDK releases after 1.2 and before 1.4.
  - `ojdbc14.jar` and `ojdbc14_g.jar`: Contain the JDBC driver classes for use with JDK 1.4.
  - `ocrs12.jar`: Contains additional support for `Rowset`.
- `Readme.txt`: Contains late-breaking and release-specific information about the drivers that might not be in this manual.

The *ORACLE_HOME*`/jlib` directory contains the following files:

- `jta.jar` and `jndi.jar`: Contain classes for the Java Transaction API and the Java Naming and Directory Interface for JDK 1.2.x, 1.3.x, and 1.4. These are only required if you will be using JTA features for distributed transaction management or JNDI features for naming services. (These files can also be obtained from the Sun Microsystems Web site, but we recommend using the versions supplied by Oracle, which have been tested with the Oracle drivers.)

Check that all these directories have been created and populated.

Check the Environment Variables

This section describes the environment variables that must be set for the JDBC OCI driver and the JDBC Thin driver, focusing on the Sun Microsystems Solaris and Microsoft Windows platforms.

You must set the `CLASSPATH` for your installed JDBC OCI or Thin driver. Depending on which JDK version you use, you must set one of these values for the `CLASSPATH`:

JDK Version	CLASSPATH
1.4	*ORACLE_HOME*`/jdbc/lib/ojdbc14.jar` for full globalization support *ORACLE_HOME*`/jdbc/lib/orai18n.jar`
1.3.x, 1.2.x	*ORACLE_HOME*`/jdbc/lib/classes12.jar` *ORACLE_HOME*`/jdbc/lib/orai18n.jar` for full globalization support

Ensure that there is only one JDBC class file (such as `classes12.jar, classes12_g.jar`, or `ojdbc14.jar`), and one globalization classes file (`orai18n.jar`) in your `CLASSPATH`.

Note: If you use JTA features or JNDI features, then you must also put `jta.jar` and `jndi.jar` in your `CLASSPATH`.

JDBC OCI Driver

If you are installing the JDBC OCI driver, you must also set the following value for the library path environment variable

- On Solaris, set `LD_LIBRARY_PATH` as follows:

  ORACLE_HOME`/lib`

  This directory contains the `libocijdbc10.so` shared object library.

  > **Note:** If you are running a 32-bit JVM against a 64-bit client or database, you must also add *ORACLE_HOME*`/lib32` to `LD_LIBRARY_PATH`.

- On Windows, set `PATH` as follows:

  ORACLE_HOME`\bin`

  This directory contains the `ocijdbc10.dll` dynamic link library.

All of the JDBC OCI demonstration programs can be run in Instant Client mode by including the JDBC OCI Instant Client Data Shared Library on the OS Library Path Variable. See Chapter 20, "OCI Instant Client" for details.

JDBC Thin Driver

If you are installing the JDBC Thin driver, you do not have to set any other environment variables.

Make Sure You Can Compile and Run Java

To further ensure that Java is set up properly on your client system, go to the `samples` directory (*ORACLE_HOME*`/jdbc/demo/samples`), then see if `javac` (the Java compiler) and `java` (the Java interpreter) will run without error. Enter:

```
javac
```

then enter:

```
java
```

Each should give you a list of options and parameters and then exit. Ideally, verify that you can compile and run a simple test program, such as `jdbc/demo/samples/generic/SelectExample`.

Determine the Version of the JDBC Driver

If at any time you must determine the version of the JDBC driver that you installed, you can invoke the `getDriverVersion()` method of the `OracleDatabaseMetaData` class.

Here is sample code showing how to do it:

```
import java.sql.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.OracleDataSource;

class JDBCVersion
{
   public static void main (String args[])
```

```
        throws SQLException
   {
   OracleDataSource ods = new OracleDataSource();
   ods.setURL("jdbc:oracle:thin:scott/tiger@host:port/service");
   Connection conn = ods.getConnection();

      // Create Oracle DatabaseMetaData object
      DatabaseMetaData meta = conn.getMetaData();

      // gets driver info:
      System.out.println("JDBC driver version is " + meta.getDriverVersion());
   }
}
```

Testing JDBC and the Database Connection: JdbcCheckup

The `samples` directory contains sample programs for a particular Oracle JDBC driver. One of the programs, `JdbcCheckup.java`, is designed to test JDBC and the database connection. The program queries you for your user name, password, and the name of a database to which you want to connect. The program connects to the database, queries for the string "`Hello World`", and prints it to the screen.

Go to the `samples` directory and compile and run `JdbcCheckup.java`. If the results of the query print without error, then your Java and JDBC installations are correct.

Although `JdbcCheckup.java` is a simple program, it demonstrates several important functions by executing the following:

- imports the necessary Java classes, including JDBC classes
- creates a `DataSource` instance
- connects to the database
- executes a simple query
- outputs the query results to your screen

"First Steps in JDBC" on page 4-1 describes these functions in greater detail. A listing of `JdbcCheckup.java` for the JDBC OCI driver appears below.

```
/*
 * This sample can be used to check the JDBC installation.
 * Just run it and provide the connect information.  It will select
 * "Hello World" from the database.
 */

// You need to import the java.sql and JDBC packages to use JDBC
import java.sql.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.OracleDataSource;

// We import java.io to be able to read from the command line
import java.io.*;
```

```
class JdbcCheckup
{
   public static void main(String args[])
          throws SQLException, IOException
   {

      // Prompt the user for connect information
      System.out.println("Please enter information to test connection to
                          the database");
      String user;
      String password;
      String database;

      user = readEntry("user: ");
      int slash_index = user.indexOf('/');
      if (slash_index != -1)
      {
         password = user.substring(slash_index + 1);
         user = user.substring(0, slash_index);
      }
      else
         password = readEntry("password: ");
      database = readEntry("database(a TNSNAME entry): ");

      System.out.print("Connecting to the database...");
      System.out.flush();

      System.out.println("Connecting...");
      // Open an OracleDataSource and get a connection
      OracleDataSource ods = new OracleDataSource();
      ods.setURL("jdbc:oracle:oci:@" + database);
      ods.setUser(user);
      ods.setPassword(password);
      Connection conn = ods.getConnection();
      System.out.println("connected.");

      // Create a statement
      Statement stmt = conn.createStatement();

      // Do the SQL "Hello World" thing
      ResultSet rset = stmt.executeQuery("select 'Hello World'
                                          from dual");

      while (rset.next())
         System.out.println(rset.getString(1));
      // close the result set, the statement and connect
      rset.close();
      stmt.close();
      conn.close();
      System.out.println("Your JDBC installation is correct.");
   }

   // Utility function to read a line from standard input
   static String readEntry(String prompt)
   {
      try
      {
         StringBuffer buffer = new StringBuffer();
         System.out.print(prompt);
         System.out.flush();
```

```
            int c = System.in.read();
            while (c != '\n' && c != -1)
            {
               buffer.append((char)c);
               c = System.in.read();
            }
            return buffer.toString().trim();
         }
         catch(IOException e)
         {
            return "";
         }
      }
   }
```

3

Datasources and URLs

This chapter discusses connecting applications to databases using JDBC datasources, as well as the URLs that describe databases. It is divided into the following sections:

Datasources

The JDBC 2.0 extension API introduced the concept of *datasources*, which are standard, general-use objects for specifying databases or other resources to use. Datasources can optionally be bound to Java Naming and Directory Interface (JNDI) entities so that you can access databases by logical names, for convenience and portability.

This functionality is a more standard and versatile alternative to the connection functionality described under "Opening a Connection to a Database" on page 4-2. The datasource facility provides a complete replacement for the previous JDBC `DriverManager` facility.

You can use both facilities in the same application, but ultimately we encourage you to transition your application to datasources. Eventually, Sun Microsystems will probably deprecate `DriverManager` and related classes and functionality.

For further introductory and general information about datasources and JNDI, refer to the Sun Microsystems specification for the JDBC 2.0 Optional Package.

A Brief Overview of Oracle Datasource Support for JNDI

The standard Java Naming and Directory Interface, or JNDI, provides a way for applications to find and access remote services and resources. These services can be any enterprise services, but for a JDBC application would include database connections and services.

JNDI allows an application to use logical names in accessing these services, removing vendor-specific syntax from application code. JNDI has the functionality to associate a logical name with a particular source for a desired service.

All Oracle JDBC datasources are JNDI-referenceable. The developer is not required to use this functionality, but accessing databases through JNDI logical names makes the code more portable.

> **Note:** Using JNDI functionality requires the file `jndi.jar` to be in the `CLASSPATH`. This file is included with the Java products on the installation CD, but is not included in the `classes12.jar` file. You must add it to the `CLASSPATH` separately. (You can also obtain it from the Sun Microsystems Web site, but it is advisable to use the version from Oracle, because that has been tested with the Oracle drivers.)

Datasource Features and Properties

With datasource functionality, using JNDI, you do not need to register the vendor-specific JDBC driver class name, and you can use logical names for URLs and other properties. This allows your application code for opening database connections to be portable to other environments.

DataSource Interface and Oracle Implementation

A JDBC datasource is an instance of a class that implements the standard `javax.sql.DataSource` interface:

```
public interface DataSource
{
   Connection getConnection() throws SQLException;
   Connection getConnection(String username, String password)
      throws SQLException;
   ...
}
```

Oracle implements this interface with the `OracleDataSource` class in the `oracle.jdbc.pool` package. The overloaded `getConnection()` method returns a physical connection to the database.

To use other values, you can set properties using appropriate setter methods discussed in the next section. For alternative user names and passwords, you can also use the `getConnection()` signature that takes these as input—this would take priority over the property settings.

> **Note:** The `OracleDataSource` class and all subclasses implement the `java.io.Serializable` and `javax.naming.Referenceable` interfaces.

DataSource Properties

The `OracleDataSource` class, as with any class that implements the `DataSource` interface, provides a set of properties that can be used to specify a database to connect to. These properties follow the JavaBeans design pattern.

Table 3–1 and Table 3–2 document `OracleDataSource` properties. The properties in Table 3–1 are standard properties according to the Sun Microsystems specification. (Be aware, however, that Oracle does not implement the standard `roleName` property.) The properties in Table 3–2 are Oracle extensions.

Table 3–1 Standard Datasource Properties

Name	Type	Description
`databaseName`	`String`	name of the particular database on the server; also known as the "SID" in Oracle terminology
`dataSourceName`	`String`	name of the underlying datasource class (for connection pooling, this is an underlying pooled connection datasource class; for distributed transactions, this is an underlying XA datasource class)
`description`	`String`	description of the datasource
`networkProtocol`	`String`	network protocol for communicating with the server; for Oracle, this applies only to the OCI drivers and defaults to `tcp` (Other possible settings include `ipc`. See the *Oracle Net Services Administrator's Guide* for more information.)
`password`	`String`	login password for the user name
`portNumber`	`int`	number of the port where the server listens for requests
`serverName`	`String`	name of the database server
`user`	`String`	name for the login account

The `OracleDataSource` class implements the following setter and getter methods for the standard properties:

- `public synchronized void setDatabaseName(String dbname)`
- `public synchronized String getDatabaseName()`
- `public synchronized void setDataSourceName(String dsname)`
- `public synchronized String getDataSourceName()`
- `public synchronized void setDescription(String desc)`
- `public synchronized String getDescription()`
- `public synchronized void setNetworkProtocol(String np)`
- `public synchronized String getNetworkProtocol()`
- `public synchronized void setPassword(String pwd)`
- `public synchronized void setPortNumber(int pn)`
- `public synchronized int getPortNumber()`
- `public synchronized void setServerName(String sn)`
- `public synchronized String getServerName()`
- `public synchronized void setUser(String user)`
- `public synchronized String getUser()`

Note that there is no `getPassword()` method, for security reasons.

Table 3–2 Oracle Extended Datasource Properties

Name	Type	Description
connectionCacheName	String	Name of cache; cannot be changed after cache has been created.
connectionCacheProperties	java.util.Properties	Properties for Implicit Connection Cache; see "Connection Cache Properties" on page 7-8.
connectionCachingEnabled	Boolean	Specifies whether Implicit Connection Cache is in use.
connectionProperties	java.util.Properties	Connection properties. See the Javadoc for a complete list.
driverType	String	Designates the Oracle JDBC driver type —one of oci, thin, or kprb (server-side internal).
fastConnectionFailoverEnabled	Boolean	Whether Fast Connection Failover is in use; see Chapter 8, "Fast Connection Failover".
implicitCachingEnabled	Boolean	Whether the implicit connection cache is enabled.
loginTimeout	int	The maximum time in seconds that this data source will wait while attempting to connect to a database.
logWriter	java.io.PrintWriter	Log writer for this datasource.
maxStatements	int	The maximum number of statements in the application cache.
serviceName	String	Database service name for this datasource.
tnsEntry	String	**(OracleXADatasource only)** The TNS entry name, relevant only for the OCI driver. The TNS entry name corresponds to the TNS entry specified in the tnsnames.ora configuration file. Enable this OracleXADataSource property when using the HeteroRM feature with the OCI driver, to access Oracle pre-8.1.6 databases and higher. The HeteroRM XA feature is described in "OCI HeteroRM XA" on page 19-9. If the tnsEntry property is not set when using the HeteroRM XA feature, an SQLException with error code ORA-17207 is thrown.
url	String	The URL of the database connect string. Provided as a convenience, it can help you migrate from an older Oracle database. You can use this property in place of the Oracle tnsEntry and driverType properties and the standard portNumber, networkProtocol, serverName, and databaseName properties.
nativeXA	Boolean	**(OracleXADatasource only)** Allows an OracleXADataSource using the HeteroRM feature with the OCI driver, to access Oracle pre-8.1.6 databases and higher. The HeteroRM XA feature is described in "OCI HeteroRM XA" on page 19-9. If the nativeXA property is enabled, be sure to set the tnsEntry property as well. This DataSource property defaults to false.

Notes: ■This table omits properties that supported the deprecated connection cache based on `OracleConnectionCache`.

- Because nativeXA performs better than JavaXA, use nativeXA whenever possible.

The `OracleDataSource` class implements the following `setXXX()` and `getXXX()` methods for the Oracle extended properties:

- `String getConnectionCacheName()`
- `java.util.Properties getConnectionCacheProperties()`
- `void setConnectionCacheProperties(java.util.Properties cp)`
- `java.util.Properties getConnectionProperties()`
- `void setConnectionProperties(java.util.Properties cp)`
- `boolean getConnectionCachingEnabled()`
- `void setImplicitCachingEnabled()`
- `void setDriverType(String dt)`
- `String getDriverType()`
- `void setURL(String url)`
- `String getURL()`
- `void setTNSEntryName(String tns)`
- `String getTNSEntryName()`
- `void setNativeXA(boolean nativeXA)`
- `boolean getNativeXA()`

If you are using the server-side internal driver—`driverType` property is set to `kprb`—then any other property settings are ignored.

If you are using the Thin or OCI drivers, note the following:

- A URL setting can include settings for `user` and `password`, as in the following example, in which case this takes precedence over individual `user` and `password` property settings:

  ```
  jdbc:oracle:thin:scott/tiger@localhost:1521:orcl
  ```

- Settings for `user` and `password` are required, either directly, through the URL setting, or through the `getConnection()` call. The `user` and `password` settings in a `getConnection()` call take precedence over any property settings.
- If the `url` property is set, then any `tnsEntry`, `driverType`, `portNumber`, `networkProtocol`, `serverName`, and `databaseName` property settings are ignored.
- If the `tnsEntry` property is set (which presumes the `url` property is not set), then any `databaseName`, `serverName`, `portNumber`, and `networkProtocol` settings are ignored.
- If you are using an OCI driver (which presumes the `driverType` property is set to `oci`) and the `networkProtocol` is set to `ipc`, then any other property settings are ignored.

Creating a Datasource Instance and Connecting (without JNDI)

This section shows an example of the most basic use of a datasource to connect to a database, without using JNDI functionality. Note that this requires vendor-specific, hard-coded property settings.

Create an `OracleDataSource` instance, initialize its connection properties as appropriate, and get a connection instance as in the following example:

```
...
OracleDataSource ods = new OracleDataSource();

ods.setDriverType("oci");
ods.setServerName("dlsun999");
ods.setNetworkProtocol("tcp");
ods.setDatabaseName("816");
ods.setPortNumber(1521);
ods.setUser("scott");
ods.setPassword("tiger");

Connection conn = ods.getConnection();
...
```

Or optionally override the user name and password:

```
...
Connection conn = ods.getConnection("bill", "lion");
...
```

Creating a Datasource Instance, Registering with JNDI, and Connecting

This section exhibits JNDI functionality in using datasources to connect to a database. Vendor-specific, hard-coded property settings are required only in the portion of code that binds a datasource instance to a JNDI logical name. From that point onward, you can create portable code by using the logical name in creating datasources from which you will get your connection instances.

> **Note:** Creating and registering datasources is typically handled by a JNDI administrator, not in a JDBC application.

Initialize Connection Properties

Create an `OracleDataSource` instance, and then initialize its connection properties as appropriate, as in the following example:

```
...
OracleDataSource ods = new OracleDataSource();

ods.setDriverType("oci");
ods.setServerName("dlsun999");
ods.setNetworkProtocol("tcp");
ods.setDatabaseName("816");
ods.setPortNumber(1521);
ods.setUser("scott");
ods.setPassword("tiger");
...
```

Register the Datasource

Once you have initialized the connection properties of the `OracleDataSource` instance `ods`, as shown in the preceding example, you can register this datasource instance with JNDI, as in the following example:

```
...
Context ctx = new InitialContext();
ctx.bind("jdbc/sampledb", ods);
...
```

Calling the JNDI `InitialContext()` constructor creates a Java object that references the initial JNDI naming context. System properties that are not shown instruct JNDI which service provider to use.

The `ctx.bind()` call binds the `OracleDataSource` instance to a logical JNDI name. This means that anytime after the `ctx.bind()` call, you can use the logical name `jdbc/sampledb` in opening a connection to the database described by the properties of the `OracleDataSource` instance `ods`. The logical name `jdbc/sampledb` is logically bound to this database.

The JNDI name space has a hierarchy similar to that of a file system. In this example, the JNDI name specifies the subcontext `jdbc` under the root naming context and specifies the logical name `sampledb` within the `jdbc` subcontext.

The `Context` interface and `InitialContext` class are in the standard `javax.naming` package.

> **Notes:** The JDBC 2.0 Specification requires that all JDBC datasources be registered in the `jdbc` naming subcontext of a JNDI namespace or in a child subcontext of the `jdbc` subcontext.

Open a Connection

To perform a lookup and open a connection to the database logically bound to the JNDI name, use the logical JNDI name. Doing this requires casting the lookup result (which is otherwise simply a Java `Object`) to a new `OracleDataSource` instance and then using its `getConnection()` method to open the connection.

Here is an example:

```
...
OracleDataSource odsconn = (OracleDataSource)ctx.lookup("jdbc/sampledb");
Connection conn = odsconn.getConnection();
...
```

Logging and Tracing

The datasource facility offers a way to register a character stream for JDBC to use as output for error logging and tracing information. This facility allows tracing specific to a particular datasource instance. If you want all datasource instances to use the same character stream, then you must register the stream with each datasource instance individually.

The `OracleDataSource` class implements the following standard datasource methods for logging and tracing:

- `public synchronized void setLogWriter(PrintWriter pw)`
- `public synchronized PrintWriter getLogWriter()`

The `PrintWriter` class is in the standard `java.io` package.

Notes:

- When a datasource instance is created, logging is disabled by default (the log stream name is initially null).
- Messages written to a log stream registered to a datasource instance are not written to the same log stream used by `DriverManager`.
- An `OracleDataSource` instance obtained from a JNDI name lookup will not have its `PrinterWriter` set, even if the `PrintWriter` was set when a datasource instance was first bound to this JNDI name.

Database URLs and Database Specifiers

Database URLs are strings. The complete URL syntax is:

`jdbc:oracle:`*`driver_type`*`:[`*`username`*`/`*`password`*`]@`*`database_specifier`*

Notes:

- The brackets indicate that the *`username`*`/`*`password`* pair is optional.
- kprb, the internal server-side driver, uses an implicit connection; database URLs for the server-side driver end after the *`driver_type`*. See "Connecting to the Database with the Server-Side Internal Driver" on page 23-15.
- The Thin driver does not support OS authentication in making the connection, and therefore does not support special logins.

The first part of the URL specifies which JDBC driver is to be used. The supported *`driver_type`* values are `thin`, `oci`, and `kprb`.

The remainder of the URL contains an optional username and password separated by a slash, an @, and the *database specifier*, which uniquely identifies the database to which the application is connected. Some database specifiers are valid only for the Thin driver, some only for the OCI driver, and some for both.

Database Specifiers

Table 3–2, " Oracle Extended Datasource Properties", shows the possible database specifiers, listing which JDBC drivers support each specifier.

Notes:

- Oracle Service IDs are no longer supported at 10*g* Release 1 (10.1).
- The Thin driver does not support Oracle Names.

Table 3–3 Supported Database Specifiers

Specifier	Supported Drivers	Example

Oracle Net connection descriptor	Thin, OCI	Thin, using an address list:
		`url="jdbc:oracle:thin:@(DESCRIPTION= (LOAD_BALANCE=on) (ADDRESS_LIST= (ADDRESS=(PROTOCOL=TCP)(HOST=host1) (PORT=1521)) (ADDRESS=(PROTOCOL=TCP)(HOST=host2)(PORT=1521))) (CONNECT_DATA=(SERVICE_NAME=service_name)))"`
		OCI, using a cluster:
		`"jdbc:oracle:oci:@(DESCRIPTION= (ADDRESS=(PROTOCOL=TCP)(HOST=cluster_alias) (PORT=1521)) (CONNECT_DATA=(SERVICE_NAME=service_name)))"`

Thin-style service name	Thin	See "Thin-style Service Name Syntax" for details. `"jdbc:oracle:thin:scott/tiger@//myhost:1521/myservicename"`

LDAP syntax	Thin	`"jdbc:oracle:thin:@ldap://ldap.acme.com:7777/sales,cn=OracleContext,dc=com"`
		or, when using SSL (see Note):
		`"jdbc:oracle:thin:@ldaps://ldap.acme.com:7777/sales,cn=OracleContext,dc=com"`

Bequeath connection	OCI	Empty -- nothing after database name `"jdbc:oracle:oci:scott/tiger"`
TNSNames alias	OCI	See "TNSNames Alias Syntax" for details.

Notes:
- For complete information on how to specify an Oracle Net connection descriptor, LDAP directory naming, or a TNS connection string, see the *Oracle Net Services Administrator's Guide*.
- The Thin driver can use LDAP over SSL to communicate with Oracle Internet Directory if you substitute `ldaps:` for `ldap:` in the database specifier. The LDAP server must be configured to use SSL; if it is not, the connection attempt will hang.

Thin-style Service Name Syntax

Thin-style service names are supported only by the Thin driver. The syntax is:

`@//host_name:port_number/service_name`

Notes: *`host_name`* can be the name of a single host or a *`cluster_alias`* .

The JDBC Thin driver supports only the TCP/IP protocol.

TNSNames Alias Syntax

You can find the available TNSNAMES entries listed in the file tnsnames.ora on the client computer from which you are connecting. On Windows, this file is located in the [*ORACLE_HOME*]\NETWORK\ADMIN directory. On UNIX systems, you can find it in the *ORACLE_HOME* directory or the directory indicated in your TNS_ADMIN environment variable.

For example, if you want to connect to the database on host myhost as user scott with password tiger that has a TNSNAMES entry of MyHostString, enter:

```
OracleDataSource ods = new OracleDataSource();
ods.setTNSEntryName("MyTNSAlias");
ods.setUser("scott");
ods.setPassword("tiger");
ods.setDriverType("oci8");
Connection conn = ods.getConnection();
```

Note: Because the JDBC Thin driver can be used in applets that do not depend on an Oracle client installation, you cannot use a TNSNAMES entry to set up a Thin driver connection.

4

Basic Features

This chapter covers the most basic steps taken in any JDBC application. It also describes additional basic features of Java and JDBC supported by the Oracle JDBC drivers.

The following topics are discussed:

- First Steps in JDBC
- Sample: Connecting, Querying, and Processing the Results
- Datatype Mappings
- Java Streams in JDBC
- Stored Procedure Calls in JDBC Programs
- Processing SQL Exceptions

First Steps in JDBC

This section describes how to get up and running with the Oracle JDBC drivers. When using the Oracle JDBC drivers, you must include certain driver-specific information in your programs. This section describes, in the form of a tutorial, where and how to add the information. The tutorial guides you through creating code to connect to and query a database from the client.

To connect to and query a database from the client, you must provide code for these tasks:

1. Importing Packages
2. Opening a Connection to a Database
3. Creating a Statement Object
4. Executing a Query and Returning a Result Set Object
5. Processing the Result Set
6. Closing the Result Set and Statement Objects
7. Making Changes to the Database
8. Committing Changes
9. Closing the Connection

You must supply Oracle driver-specific information for the first three tasks, which allow your program to use the JDBC API to access a database. For the other tasks, you can use standard JDBC Java code as you would for any Java application.

Importing Packages

Regardless of which Oracle JDBC driver you use, include the `import` statements shown in Table 4–1 at the beginning of your program:

Table 4–1 Import Statements for JDBC Driver

Import statement	Required by
`import java.sql.*;`	standard JDBC packages
`import java.math.*;`	`BigDecimal` and `BigInteger` classes (you can omit this import if you don't use these classes)
`import oracle.jdbc.*;`	(optional) Oracle extensions to JDBC
`import oracle.jdbc.pool.*;`	
`import oracle.sql.*;`	

The Oracle packages listed as optional provide access to the extended functionality provided by the Oracle drivers, but are not required for the example presented in this section. For an overview of the Oracle extensions to the JDBC standard, see Chapter 10, "Oracle Extensions".

Opening a Connection to a Database

You create an `OracleDataSource` using its constructor. You then open a connection to the database using `OracleDataSource.getConnection()`. The retrieved connection properties are derived from the `OracleDataSource` instance. See Table 4–2, " Connection Properties Recognized by Oracle JDBC Drivers" for the detailed list of connection properties. If you set the URL connection property, all other properties, including `TNSEntryName`, `DatabaseName`, `ServiceName`, `ServerName`, `PortNumber`, `Network Protocol`, and driver type are ignored. The syntax of the URL is discussed in Chapter 3, "Datasources and URLs"

Open a connection to the database using the JDBC `DataSource` class. To create a connection, you must specify a connection string containing a database URL.

Specifying a Database URL, User Name, and Password

The following code sets the URL, user name, and password for a datasource:

```
OracleDataSource ods = new OracleDataSource();
ods.setURL(URL);
ods.setUser(user);
ods.setPassword(password);
```

(For URL format, see Chapter 3, "Datasources and URLs".)

The following example connects user `scott` with password `tiger` to a database with service `orcl` through port 1521 of host `myhost`, using the Thin driver.

```
OracleDataSource ods = new OracleDataSource();
String URL = "jdbc:oracle:thin:@//myhost:1521/orcl",
ods.setURL(URL);
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();
```

Note: The username and password specified in the arguments override any username and specified in the URL.

Specifying a Database URL That Includes User Name and Password

The following example connects user `scott` with password `tiger` to a database host whose TNS entry is `myTNSEntry` using the OCI driver. In this case, however, the URL includes the userid and password, and is the only input parameter.

```
String URL = "jdbc:oracle:oci:scott/tiger@myTNSEntry");
ods.setURL(URL);
Connection conn = ods.getConnection();
```

If you want to connect using the Thin driver you must specify the port number. For example, if you want to connect to the database on host `myhost` that has a TCP/IP listener up on port 1521 and the service identifier is `orcl`:

```
String URL = "jdbc:oracle:thin:scott/tiger@//myhost:1521/orcl");
ods.setURL(URL);
Connection conn = ods.getConnection();
```

Supported Connection Properties

Table 4–2 lists the connection properties that Oracle JDBC drivers support.

Table 4–2 Connection Properties Recognized by Oracle JDBC Drivers

Name	Type	Description
`accumulateBatchResult`	String (containing boolean value)	"true" causes the number of modified rows used to determine when to flush a batch accumulates across all batches flushed from a single statement. The default is "false", counting each batch separately
`database`	String	connect string for the database
`defaultBatchValue`	String (containing integer value)	default batch value that triggers an execution request (default value is "10")
`defaultExecuteBatch`	String (containing integer value)	default batch size when using Oracle batching
`defaultNchar`	String (containing boolean value)	"true" causes the default mode for all character data columns to be `NCHAR`.
`defaultRowPrefetch`	String (containing integer value)	default number of rows to prefetch from the server (default value is "10")

Table 4–2 (Cont.) Connection Properties Recognized by Oracle JDBC Drivers

Name	Type	Description
`disableDefineColumnType`	String (containing boolean value)	"true" causes `defineColumnType()` to have no effect. This is highly recommended when using the Thin driver, especially when the database character set contains four byte characters that expand to two UCS2 surrogate characters, e.g. AL32UTF8. The method `defineColumnType()` provides no performance benefit (or any other benefit) when used with the 10*g* Release 1 (10.1) Thin driver. This property is provided so that you do not have to remove the calls from your code. This is especially valuable if you use the same code with Thin driver and either the OCI or Server Internal driver.
`DMSName`	String	name of the DMS Noun that is the parent of all JDBC DMS metrics. (see Note.)
`DMSType`	String	type of the DMS Noun that is the parent of all JDBC DMS metrics. (see Note.)
`fixedString`	String (containing boolean value)	"true" causes JDBC to use `FIXED CHAR` semantics when `setObject()` is called with a `String` argument. By default JDBC uses `VARCHAR` semantics. The difference is in blank padding. By default there is no blank padding. For example, 'a' does not equal 'a ' in a `CHAR(4)` unless `fixedString` is "true".
`includeSynonyms`	String (containing boolean value)	"true" to include column information from predefined "synonym" SQL entities when you execute a `DataBaseMetaData getColumns()` call; equivalent to connection `setIncludeSynonyms()` call (default value is "false")
`internal_logon`	String	username used in an internal logon. Must be the role, such as `sysdba` or `sysoper`, that allows you to log on as `sys`
`oracle.jdbc.J2EE13Compliant`	String (containing boolean value)	true" causes JDBC to use strict compliance for some edge cases. In general, Oracle's JDBC drivers allow some operations that are not permitted in the strict interpretation of J2EE 1.3. Setting this property to "true" will cause those cases to throw `SQLExceptions`. There are some other edge cases where Oracle's JDBC drivers have slightly different behavior than defined in J2EE 1.3. This results from Oracle having defined the behavior prior to the J2EE 1.3 specification and the resultant need for compatibility with existing customer code. Setting this property will result in full J2EE 1.3 compliance at the cost of incompatibility with some customer code. Can be either a system property or a connection property.

Table 4–2 (Cont.) Connection Properties Recognized by Oracle JDBC Drivers

Name	Type	Description
`oracle.jdbc.TcpNoDelay`	String (containing boolean value)	"true" causes the `TCP_NODELAY` property is set on the socket when using the Thin driver. See `java.net.SocketOptions.TCP_NODELAY`. Can be either a system property or a connection property.
`oracle.jdbc.ocinativelibrary`	String	name of the native library for the OCI driver. If not set, the default name, `libocijdbc`*X* (*X* is the version number), is used.
`password`	String	the password for logging into the database
`processEscapes`	String (containing boolean value)	"true" if escape processing is enabled for all statements, "false" if escape processing is disabled (default value is "false")
`remarksReporting`	String (containing boolean value)	"true" if `getTables()` and `getColumns()` should report `TABLE_REMARKS`; equivalent to using `setRemarksReporting()` (default value is "false")
`remarksReporting`	String (containing boolean value)	"true" causes `OracleDatabaseMetaData` to include remarks in the metadata. This can result in a substantial reduction in performance.
`restrictGetTables`	String (containing boolean value)	"true" causes JDBC to return a more refined value for `DatabaseMeta.getTables()`. By default JDBC will return things that are not accessible tables. These can be non-table objects or accessible synonyms for inaccessible tables. If this property is "true", JDBC returns only accessible tables. This has a substantial performance penalty.
`server`	String	hostname of database
`useFetchSizeWithLongColumn`	String (containing boolean value)	"true" causes JDBC to prefetch rows even when there is a LONG or LONG RAW column in the result. By default JDBC fetches only one row at a time if there are LONG or LONG RAW columns in the result. Setting this property to true can improve performance but can also cause `SQLExceptions` if the results are too big. We recommend avoiding LONG and LONG RAW columns; use LOB instead.
`user`	String	user name for logging into the database

See Table 23–2, " OCI Driver Client Parameters for Encryption and Integrity" and Table 23–3, " Thin Driver Client Parameters for Encryption and Integrity" for descriptions of encryption and integrity drivers.

Using Roles for Sys Logon

To specify the role (mode) for `sys` logon, use the `internal_logon` connection property. (See Table 4–2, " Connection Properties Recognized by Oracle JDBC Drivers", for a

complete description of this connection property.) To logon as `sys`, set the `internal_logon` connection property to `sysdba` or `sysoper`.

> **Note:** The ability to specify a role is supported only for `sys` user name.

For a bequeath connection, we can get a connection as "sys" by setting the `internal_logon` property. For a remote connection, we need additional password file setting procedures.

Configuring To Permit Use of sysdba

Before the Thin driver can connect to the database as `sysdba`, you must configure the user as follows:

1. From the command line, type:

   ```
   orapwd file=$ORACLE_HOME/dbs/orapw password=yourpass entries=5
   ```

2. In SQLPLUS, connect / as sysdba.
   - To grant sysdba to a user *Username*, type:

     ```
     grant SYSDBA to Username
     ```

   - To grant sysdba to sys, type:

     ```
     ALTER USER sys IDENTIFIED BY yourpass
     ```

3. Edit `init.ora` and add the line:

   ```
   REMOTE_LOGIN_PASSWORDFILE=EXCLUSIVE
   ```

Bequeath Connection and Sys Logon

The following example illustrates how to use the `internal_logon` and `sysdba` arguments to specify sys logon. This example works regardless of the database's national-language settings.

```
/** Example of bequeath connection **/
import java.sql.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.*;

// create an OracleDataSource instance
OracleDataSource ods = new OracleDataSource();

// set neccessary properties
java.util.Properties prop = new java.util.Properties();
prop.put("user", "sys");
prop.put("password", "sys");
prop.put("internal_logon", "sysdba");
ods.setConnectionProperties(prop);

// the url for bequeath connection
String url = "jdbc:oracle:oci8:@";
ods.setURL(url);
```

```
// retrieve the connection
Connection conn = ods.getConnection();
...
```

Remote Connection

Password file pre-procedures are needed for getting connected to a remote database as user SYS, because the Oracle database security system requires a password file for remote connections as an administrator.

1. Set a password file on the server side, or on the remote database, using the password utility `orapwd`. You can add a password file for user `sys` as follows:

   ```
   (UNIX) orapwd file=$ORACLE_HOME/dbs/orapw password=sys entries=200
   (WINDOWS) orapwd file=$ORACLE_HOME\database\PWDsid_name.ora
      password=sys entries=200
   ```

   Please refer to the *Oracle Database Administrator's Guide* for its details. `file` must be the name of the password file. `password` is the password for the user sys. It can be altered using "`alter user ...`" in SQLPlus. You should set `entries` higher than the number of entries you expect.

   The syntax for the password file name is different on Windows than on Unix.

2. Enable remote login as `sysdba`. This step grants `SYSDBA` and `SYSOPER` system privileges to individual users and lets them connect as themselves.

   Stop the database. Then add the following line to (UNIX) `init`*`service_name`*`.ora` (Windows) `init.ora`:

   ```
   remote_login_passwordfile=exclusive
   ```

   The `init`*`service_name`*`.ora` file is located at *`ORACLE_HOME`*`/dbs/`and also at *`ORACLE_HOME`*`/admin/db_name/pfile/`. Keep the two files synchronized.

   The `init.ora` file is located at `%ORACLE_BASE%\ADMIN\db_name\pfile\`.

3. (Optional) Change the password for the sys user

   ```
   SQL> alter user sys identified by sys;
   ```

4. Verify whether `sys` has the `sysdba` privilege. The following message should come up:

   ```
   SQL> select * from v$pwfile_users;
   USERNAME                  SYSDB   SYSOP
   ----------------------           ---------    ---------
   SYS                               TRUE    TRUE
   ```

5. Restart the remote database.

Example 4–1 Using sys Logon To Make a Remote Connection

```
This example works regardless of database's language settings
 /** case of remote connection using sys **/
import java.sql.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.*;
// create an OracleDataSource
OracleDataSource ods = new OracleDataSource();
// set connection properties
java.util.Properties prop = new java.util.Properties();
prop.put("user", "sys");
prop.put("password", "sys");
prop.put("internal_logon", "sysoper");
ods.setConnectionProperties(prop);
// set the url
// the url can use oci driver as well as:
// url = "jdbc:oracle:oci8:@inst1"; the inst1 is a remote database
String url = "jdbc:oracle:thin:@//myHost:1521/service_name";
ods.setURL(url);
// get the connection
Connection conn = ods.getConnection();
```

Properties for Oracle Performance Extensions

Some of these properties are for use with Oracle performance extensions. Setting these properties is equivalent to using corresponding methods on the `OracleConnection` object, as follows:

- Setting the `defaultRowPrefetch` property is equivalent to calling `setDefaultRowPrefetch()`.

  See "Oracle Row Prefetching" on page 22-15.

- Setting the `remarksReporting` property is equivalent to calling `setRemarksReporting()`.

  See "DatabaseMetaData TABLE_REMARKS Reporting" on page 22-20.

- Setting the `defaultBatchValue` property is equivalent to calling `setDefaultExecuteBatch()`.

  See "Oracle Update Batching" on page 22-3.

Example The following example shows how to use the `put()` method of the `java.util.Properties` class, in this case to set Oracle performance extension parameters.

```
//import packages and register the driver
import java.sql.*;
import java.math.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.OracleDataSource;

//specify the properties object
java.util.Properties info = new java.util.Properties();
info.put ("user", "scott");
info.put ("password", "tiger");
info.put ("defaultRowPrefetch","20");
info.put ("defaultBatchValue", "5");
```

```
//specify the datasource object
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:thin:@//myhost:1521/orcl");
ods.setUser("scott");
ods.setPassword("tiger");
...
```

Creating a Statement Object

Once you connect to the database and, in the process, create your `Connection` object, the next step is to create a `Statement` object. The `createStatement()` method of your JDBC `Connection` object returns an object of the JDBC `Statement` class. To continue the example from the previous section where the `Connection` object `conn` was created, here is an example of how to create the `Statement` object:

```
Statement stmt = conn.createStatement();
```

Note that there is nothing Oracle-specific about this statement; it follows standard JDBC syntax.

Executing a Query and Returning a Result Set Object

To query the database, use the `executeQuery()` method of your `Statement` object. This method takes a SQL statement as input and returns a JDBC `ResultSet` object.

To continue the example, once you create the `Statement` object `stmt`, the next step is to execute a query that populates a `ResultSet` object with the contents of the `ENAME` (employee name) column of a table of employees named `EMP`:

```
ResultSet rset = stmt.executeQuery ("SELECT ename FROM emp");
```

Again, there is nothing Oracle-specific about this statement; it follows standard JDBC syntax.

Processing the Result Set

Once you execute your query, use the `next()` method of your `ResultSet` object to iterate through the results. This method steps through the result set row by row, detecting the end of the result set when it is reached.

To pull data out of the result set as you iterate through it, use the appropriate `getXXX()` methods of the `ResultSet` object, where `XXX` corresponds to a Java datatype.

For example, the following code will iterate through the `ResultSet` object `rset` from the previous section and will retrieve and print each employee name:

```
while (rset.next())
   System.out.println (rset.getString(1));
```

Once again, this is standard JDBC syntax. The `next()` method returns false when it reaches the end of the result set. The employee names are materialized as Java strings.

Closing the Result Set and Statement Objects

You must explicitly close the `ResultSet` and `Statement` objects after you finish using them. This applies to all `ResultSet` and `Statement` objects you create when using the Oracle JDBC drivers. The drivers do not have finalizer methods; cleanup routines are performed by the `close()` method of the `ResultSet` and `Statement` classes. If you do not explicitly close your `ResultSet` and `Statement` objects, serious memory leaks

could occur. You could also run out of cursors in the database. Closing both the result set and the statement releases the corresponding cursor in the database; if you close only the result set, the cursor is not released.

For example, if your `ResultSet` object is `rset` and your `Statement` object is `stmt`, close the result set and statement with these lines:

```
rset.close();
stmt.close();
```

When you close a `Statement` object that a given `Connection` object creates, the connection itself remains open.

Note: Typically, you should put `close()` statements in a `finally` clause.

Making Changes to the Database

To write changes to the database, such as for `INSERT` or `UPDATE` operations, you will typically create a `PreparedStatement` object. This allows you to execute a statement with varying sets of input parameters. The `prepareStatement()` method of your JDBC `Connection` object allows you to define a statement that takes variable bind parameters, and returns a JDBC `PreparedStatement` object with your statement definition.

Use the `setXXX()` methods on the `PreparedStatement` object to bind data into the prepared statement to be sent to the database. The various `setXXX()` methods are described in "The setObject() and setOracleObject() Methods" on page 11-9 and "Other setXXX() Methods" on page 11-9.

Note that there is nothing Oracle-specific about the functionality described here; it follows standard JDBC syntax.

The following example shows how to use a prepared statement to execute `INSERT` operations that add two rows to the `EMP` table.

```
// Prepare to insert new names in the EMP table
PreparedStatement pstmt =
  conn.prepareStatement ("insert into EMP (EMPNO, ENAME) values (?, ?)");

// Add LESLIE as employee number 1500
pstmt.setInt (1, 1500);          // The first ? is for EMPNO
pstmt.setString (2, "LESLIE");   // The second ? is for ENAME
// Do the insertion
pstmt.execute ();

// Add MARSHA as employee number 507
pstmt.setInt (1, 507);           // The first ? is for EMPNO
pstmt.setString (2, "MARSHA");   // The second ? is for ENAME
// Do the insertion
pstmt.execute ();

// Close the statement
pstmt.close();
```

Committing Changes

By default, DML operations (`INSERT`, `UPDATE`, `DELETE`) are committed automatically as soon as they are executed. This is known as *auto-commit* mode. You can, however, disable auto-commit mode with the following method call on the `Connection` object:

```
conn.setAutoCommit(false);
```

(For further discussion of auto-commit mode and an example of disabling it, see "Disabling Auto-Commit Mode" on page 26-4.)

If you disable auto-commit mode, then you must manually commit or roll back changes with the appropriate method call on the `Connection` object:

```
conn.commit();
```

or:

```
conn.rollback();
```

A `COMMIT` or `ROLLBACK` operation affects all DML statements executed since the last `COMMIT` or `ROLLBACK`.

Important:

- If auto-commit mode is disabled and you close the connection without explicitly committing or rolling back your last changes, then an implicit `COMMIT` operation is executed.
- Any DDL operation, such as `CREATE` or `ALTER`, always includes an implicit `COMMIT`. If auto-commit mode is disabled, this implicit `COMMIT` will not only commit the DDL statement, but also any pending DML operations that had not yet been explicitly committed or rolled back.

Closing the Connection

You must close your connection to the database once you finish your work. Use the `close()` method of the `Connection` object to do this:

```
conn.close();
```

Note: Typically, you should put `close()` statements in a `finally` clause.

Sample: Connecting, Querying, and Processing the Results

The steps in the preceding sections are illustrated in the following example, which uses Oracle JDBC Thin driver to create a datasource, connects to the database, creates a `Statement` object, executes a query, and processes the result set.

Note that the code for creating the `Statement` object, executing the query, returning and processing the `ResultSet` object, and closing the statement and connection all follow standard JDBC syntax.

```
import java.sql.*;
import java.math.*;
import java.io.*;
import java.awt.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.OracleDataSource;

class JdbcTest {
   public static void main (String args []) throws SQLException {
      // Create DataSource and connect to the local database
      OracleDataSource ods = new OracleDataSource();
      ods.setURL("jdbc:oracle:thin:@//myhost:1521/orcl");
      ods.setUser("scott");
      ods.setPassword("tiger");
      Connection conn = ods.getConnection();

      // Query the employee names
      Statement stmt = conn.createStatement ();
      ResultSet rset = stmt.executeQuery ("SELECT ename FROM emp");
      // Print the name out
      while (rset.next ())
         System.out.println (rset.getString (1));

      //close the result set, statement, and the connection
      rset.close();
      stmt.close();
      conn.close();
   }
}
```

If you want to adapt the code for the OCI driver, replace the `OracleDataSource.setURL()` invocation with the following:

```
ods.setURL("jdbc:oracle:oci:@MyHostString");
```

Where `MyHostString` is an entry in the `TNSNAMES.ORA` file.

Datatype Mappings

The Oracle JDBC drivers support standard JDBC types as well as Oracle-specific `BFILE` and `ROWID` datatypes and types of the `REF CURSOR` category.

This section documents standard and Oracle-specific SQL-Java default type mappings.

Table of Mappings

For reference, Table 4–3 shows the default mappings between SQL datatypes, JDBC typecodes, standard Java types, and Oracle extended types.

The **SQL Datatypes** column lists the SQL types that exist in the 10*g* Release 1 (10.1) database.

The **JDBC Typecodes** column lists data typecodes supported by the JDBC standard and defined in the `java.sql.Types` class, or by Oracle in the `oracle.jdbc.OracleTypes` class. For standard typecodes, the codes are identical in these two classes.

The **Standard Java Types** column lists standard types defined in the Java language.

The **Oracle Extension Java Types** column lists the `oracle.sql.*` Java types that correspond to each SQL datatype in the database. These are Oracle extensions that let you retrieve all SQL data in the form of a `oracle.sql.*` Java type. Mapping SQL datatypes into the `oracle.sql` datatypes lets you store and retrieve data without losing information. Refer to "Package oracle.sql" on page 10-5 for more information on the `oracle.sql.*` package.

Table 4–3 Default Mappings Between SQL Types and Java Types

SQL Datatypes	JDBC Typecodes	Standard Java Types	Oracle Extension Java Types
	STANDARD JDBC 1.0 TYPES:		
CHAR	java.sql.Types.CHAR	java.lang.String	oracle.sql.CHAR
VARCHAR2	java.sql.Types.VARCHAR	java.lang.String	oracle.sql.CHAR
LONG	java.sql.Types.LONGVARCHAR	java.lang.String	oracle.sql.CHAR
NUMBER	java.sql.Types.NUMERIC	java.math.BigDecimal	oracle.sql.NUMBER
NUMBER	java.sql.Types.DECIMAL	java.math.BigDecimal	oracle.sql.NUMBER
NUMBER	java.sql.Types.BIT	boolean	oracle.sql.NUMBER
NUMBER	java.sql.Types.TINYINT	byte	oracle.sql.NUMBER
NUMBER	java.sql.Types.SMALLINT	short	oracle.sql.NUMBER
NUMBER	java.sql.Types.INTEGER	int	oracle.sql.NUMBER
NUMBER	java.sql.Types.BIGINT	long	oracle.sql.NUMBER
NUMBER	java.sql.Types.REAL	float	oracle.sql.NUMBER
NUMBER	java.sql.Types.FLOAT	double	oracle.sql.NUMBER
NUMBER	java.sql.Types.DOUBLE	double	oracle.sql.NUMBER
RAW	java.sql.Types.BINARY	byte[]	oracle.sql.RAW
RAW	java.sql.Types.VARBINARY	byte[]	oracle.sql.RAW
LONGRAW	java.sql.Types.LONGVARBINARY	byte[]	oracle.sql.RAW
DATE	java.sql.Types.DATE	java.sql.Date	oracle.sql.DATE
DATE	java.sql.Types.TIME	java.sql.Time	oracle.sql.DATE
TIMESTAMP	java.sql.Types.TIMESTAMP	javal.sql.Timestamp	oracle.sql.TIMESTAMP (see Note)
	STANDARD JDBC 2.0 TYPES:		
BLOB	java.sql.Types.BLOB	java.sql.Blob	oracle.sql.BLOB
CLOB	java.sql.Types.CLOB	java.sql.Clob	oracle.sql.CLOB
user-defined object	java.sql.Types.STRUCT	java.sql.Struct	oracle.sql.STRUCT

Table 4–3 (Cont.) Default Mappings Between SQL Types and Java Types

SQL Datatypes	JDBC Typecodes	Standard Java Types	Oracle Extension Java Types
user-defined reference	java.sql.Types.REF	java.sql.Ref	oracle.sql.REF
user-defined collection	java.sql.Types.ARRAY	java.sql.Array	oracle.sql.ARRAY
	ORACLE EXTENSIONS:		
BFILE	oracle.jdbc.OracleTypes.BFILE	n/a	oracle.sql.BFILE
ROWID	oracle.jdbc.OracleTypes.ROWID	n/a	oracle.sql.ROWID
REF CURSOR type	oracle.jdbc.OracleTypes.CURSOR	java.sql.ResultSet	oracle.jdbc.OracleResultSet
TIMESTAMP	oracle.jdbc.OracleTypes.TIMESTAMP	java.sql.Timestamp	oracle.sql.TIMESTAMP
TIMESTAMP WITH TIME ZONE	oracle.jdbc.OracleTypes.TIMESTAMPTZ	java.sql.Timestamp	oracle.sql.TIMESTAMPTZ
TIMESTAMP WITH LOCAL TIME ZONE	oracle.jdbc.OracleTypes.TIMESTAMPLTZ	java.sql.Timestamp	oracle.sql.TIMESTAMPLTZ

Note: For database versions, such as 8.1.7, that do not support the `TIMESTAMP` datatype, this is mapped to `DATE`.

For a list of all the Java datatypes to which you can validly map a SQL datatype, see "Valid SQL-JDBC Datatype Mappings" on page 24-1.

See Chapter 10, "Oracle Extensions", for more information on type mappings. In Chapter 10 you can also find more information on the following:

- packages `oracle.sql` and `oracle.jdbc`
- type extensions for the Oracle `BFILE` and `ROWID` datatypes and user-defined types of the `REF CURSOR` category

Notes Regarding Mappings

This section goes into further detail regarding mappings for `NUMBER` and user-defined types.

Regarding User-Defined Types

User-defined types such as objects, object references, and collections map by default to weak Java types (such as `java.sql.Struct`), but alternatively can map to strongly typed *custom Java classes*. Custom Java classes can implement one of two interfaces:

- The standard `java.sql.SQLData` (for user-defined objects only)
- The Oracle-specific `oracle.sql.ORAData` (primarily for user-defined objects, object references, and collections, but able to map from *any* SQL type where you want customized processing of any kind)

For information about custom Java classes and the `SQLData` and `ORAData` interfaces, see "Mapping Oracle Objects" on page 13-1 and "Creating and Using Custom Object

Classes for Oracle Objects" on page 13-7. (Although these sections focus on custom Java classes for user-defined objects, there is some general information about other kinds of custom Java classes as well.)

Regarding NUMBER Types

For the different typecodes that an Oracle `NUMBER` value can correspond to, call the getter routine that is appropriate for the size of the data for mapping to work properly. For example, call `getByte()` to get a Java `tinyint` value, for an item `x` where -128 < x < 128.

Java Streams in JDBC

This section covers the following topics:

- Streaming LONG or LONG RAW Columns
- Streaming CHAR, VARCHAR, or RAW Columns
- Data Streaming and Multiple Columns
- Streaming and Row Prefetching
- Closing a Stream
- Streaming LOBs and External Files

This section describes how the Oracle JDBC drivers handle Java streams for several datatypes. Data streams allow you to read `LONG` column data of up to 2 gigabytes. Methods associated with streams let you read the data incrementally.

Oracle JDBC drivers support the manipulation of data streams in either direction between server and client. The drivers support all stream conversions: binary, ASCII, and Unicode. Following is a brief description of each type of stream:

- binary stream—Used for `RAW` bytes of data. This corresponds to the `getBinaryStream()` method.
- ASCII stream—Used for ASCII bytes in ISO-Latin-1 encoding. This corresponds to the `getAsciiStream()` method.
- Unicode stream—Used for Unicode bytes with the `UTF-16` encoding. This corresponds to the `getUnicodeStream()` method.

The methods `getBinaryStream()`, `getAsciiStream()`, and `getUnicodeStream()` return the bytes of data in an `InputStream` object. These methods are described in greater detail in Chapter 14, "Working with LOBs and BFILEs".

Streaming LONG or LONG RAW Columns

When a query selects one or more `LONG` or `LONG RAW` columns, the JDBC driver transfers these columns to the client in streaming mode. After a call to `executeQuery()` or `next()`, the data of the `LONG` column is waiting to be read.

To access the data in a `LONG` column, you can get the column as a Java `InputStream` and use the `read()` method of the `InputStream` object. As an alternative, you can get the data as a string or byte array, in which case the driver will do the streaming for you.

You can get `LONG` and `LONG RAW` data with any of the three stream types. The driver performs conversions for you, depending on the character set of your database and the

driver. For more information about globalization support, see "JDBC Methods Dependent On Conversion" on page 12-3.

> **Note:** Do not create tables with `LONG` columns. Use LOB columns (`CLOB`, `NCLOB`, `BLOB`) instead. `LONG` columns are supported only for backward compatibility. Oracle Corporation also recommends that you convert existing `LONG` columns to `LOB` columns. `LOB` columns are subject to far fewer restrictions than `LONG` columns. Further, LOB functionality is enhanced in every release, whereas `LONG` functionality has been static for several releases.

LONG RAW Data Conversions

A call to `getBinaryStream()` returns `RAW` data "as-is". A call to `getAsciiStream()` converts the `RAW` data to hexadecimal and returns the ASCII representation. A call to `getUnicodeStream()` converts the `RAW` data to hexadecimal and returns the Unicode bytes.

LONG Data Conversions

When you get `LONG` data with `getAsciiStream()`, the drivers assume that the underlying data in the database uses an `US7ASCII` or `WE8ISO8859P1` character set. If the assumption is true, the drivers return bytes corresponding to ASCII characters. If the database is not using an `US7ASCII` or `WE8ISO8859P1` character set, a call to `getAsciiStream()` returns meaningless information.

When you get `LONG` data with `getUnicodeStream()`, you get a stream of Unicode characters in the `UTF-16` encoding. This applies to all underlying database character sets that Oracle supports.

When you get `LONG` data with `getBinaryStream()`, there are two possible cases:

- If the driver is JDBC OCI and the client character set is not `US7ASCII` or `WE8ISO8859P1`, then a call to `getBinaryStream()` returns `UTF-8`. If the client character set is `US7ASCII` or `WE8ISO8859P1`, then the call returns a `US7ASCII` stream of bytes.
- If the driver is JDBC Thin and the database character set is not `US7ASCII` or `WE8ISO8859P1`, then a call to `getBinaryStream()` returns `UTF-8`. If the server-side character set is `US7ASCII` or `WE8ISO8859P1`, then the call returns a `US7ASCII` stream of bytes.

For more information on how the drivers return data based on character set, see Chapter 12, "Globalization Support".

> **Note:** Receiving `LONG` or `LONG RAW` columns as a stream (the default case) requires you to pay special attention to the order in which you receive data from the database. For more information, see "Data Streaming and Multiple Columns" on page 4-19.

Table 4–4 summarizes LONG and LONG RAW data conversions for each stream type.

Table 4–4 LONG and LONG RAW Data Conversions

Datatype	BinaryStream	AsciiStream	UnicodeStream
LONG	bytes representing characters in Unicode UTF-8. The bytes can represent characters in US7ASCII or WE8ISO8859P1 if: ▪ the database character set is US7ASCII or WE8ISO8859P1.	bytes representing characters in ISO-Latin-1 (WE8ISO8859P1) encoding	bytes representing characters in Unicode UTF-16 encoding
LONG RAW	as-is	ASCII representation of hexadecimal bytes	Unicode representation of hexadecimal bytes

Streaming Example for LONG RAW Data

One of the features of a getXXXStream() method is that it allows you to fetch data incrementally. In contrast, getBytes() fetches all the data in one call. This section contains two examples of getting a stream of binary data. The first version uses the getBinaryStream() method to obtain LONG RAW data; the second version uses the getBytes() method.

Getting a LONG RAW Data Column with getBinaryStream() This Java example writes the contents of a LONG RAW column to a file on the local file system. In this case, the driver fetches the data incrementally.

The following code creates the table that stores a column of LONG RAW data associated with the name LESLIE:

```
-- SQL code:
create table streamexample (NAME varchar2 (256), GIFDATA long raw);
insert into streamexample values ('LESLIE', '00010203040506070809');
```

The following Java code snippet writes the data from the LESLIE LONG RAW column into a file called leslie.gif:

```
ResultSet rset = stmt.executeQuery
                 ("select GIFDATA from streamexample where NAME='LESLIE'");

// get first row
if (rset.next())
{
    // Get the GIF data as a stream from Oracle to the client
    InputStream gif_data = rset.getBinaryStream (1);
   try
   {
      FileOutputStream file = null;
      file = new FileOutputStream ("leslie.gif");
      int chunk;
      while ((chunk = gif_data.read()) != -1)
         file.write(chunk);
   }
   catch (Exception e)
   {
      String err = e.toString();
      System.out.println(err);
   }
```

```
   finally
   {
      if file != null()
         file.close();
   }
}
```

In this example the contents of the `GIFDATA` column are transferred incrementally in `chunk`-sized pieces between the database and the client. The `InputStream` object returned by the call to `getBinaryStream()` reads the data directly from the database connection.

Getting a LONG RAW Data Column with getBytes() This version of the example gets the content of the `GIFDATA` column with `getBytes()` instead of `getBinaryStream()`. In this case, the driver fetches all the data in one call and stores it in a byte array. The previous code snippet can be rewritten as:

```
ResultSet rset2 = stmt.executeQuery
                  ("select GIFDATA from streamexample where NAME='LESLIE'");

// get first row
if (rset2.next())
{
   // Get the GIF data as a stream from Oracle to the client
   byte[] bytes = rset2.getBytes(1);
   try
   {
      FileOutputStream file = null;
      file = new FileOutputStream ("leslie2.gif");
      file.write(bytes);
   }
   catch (Exception e)
   {
      String err = e.toString();
      System.out.println(err);
   }
   finally
   {
      if file != null()
         file.close();
   }
}
```

Because a `LONG RAW` column can contain up to 2 gigabytes of data, the `getBytes()` example will probably use much more memory than the `getBinaryStream()` example. Use streams if you do not know the maximum size of the data in your `LONG` or `LONG RAW` columns.

Avoiding Streaming for LONG or LONG RAW

The JDBC driver automatically streams any `LONG` and `LONG RAW` columns. However, there may be situations where you want to avoid data streaming. For example, if you have a very small `LONG` column, you might want to avoid returning the data incrementally and instead, return the data in one call.

To avoid streaming, use the `defineColumnType()` method to redefine the type of the `LONG` column. For example, if you redefine the `LONG` or `LONG RAW` column as type `VARCHAR` or `VARBINARY`, then the driver will not automatically stream the data.

If you redefine column types with `defineColumnType()`, you must declare the types of *all* columns in the query. If you do not, `executeQuery()` will fail. In addition, you must cast the `Statement` object to an `oracle.jdbc.OracleStatement` object.

As an added benefit, using `defineColumnType()` saves the driver two round trips to the database when executing the query. Without `defineColumnType()`, the JDBC driver has to request the datatypes of the column types.

Using the example from the previous section, the `Statement` object `stmt` is cast to the `OracleStatement` and the column containing `LONG RAW` data is redefined to be of the type `VARBINARAY`. The data is not streamed—instead, it is returned in a byte array.

```
//cast the statement stmt to an OracleStatement
oracle.jdbc.OracleStatement ostmt =
   (oracle.jdbc.OracleStatement)stmt;

//redefine the LONG column at index position 1 to VARBINARY
ostmt.defineColumnType(1, Types.VARBINARY);

// Do a query to get the images named 'LESLIE'
ResultSet rset = ostmt.executeQuery
         ("select GIFDATA from streamexample where NAME='LESLIE'");

// The data is not streamed here
rset.next();
byte [] bytes = rset.getBytes(1);
```

Streaming CHAR, VARCHAR, or RAW Columns

If you use the `defineColumnType()` Oracle extension to redefine a `CHAR`, `VARCHAR`, or `RAW` column as a `LONGVARCHAR` or `LONGVARBINARY`, then you can get the column as a stream. The program will behave as if the column were actually of type `LONG` or `LONG RAW`. Note that there is not much point to this, because these columns are usually short.

If you try to get a `CHAR`, `VARCHAR`, or `RAW` column as a data stream without redefining the column type, the JDBC driver will return a Java `InputStream`, but no real streaming occurs. In the case of these datatypes, the JDBC driver fully fetches the data into an in-memory buffer during a call to the `executeQuery()` method or `next()` method. The `getXXXStream()` entry points return a stream that reads data from this buffer.

Data Streaming and Multiple Columns

If your query selects multiple columns and one of the columns contains a data stream, then the contents of the columns following the stream column are not available until the stream has been read, and the stream column is no longer available once any following column is read. Any attempt to read a column beyond a streaming column closes the streaming column. See "Streaming Data Precautions" on page 4-22 for more information.

Streaming Example with Multiple Columns

Consider the following query:

```
ResultSet rset = stmt.executeQuery
        ("select DATECOL, LONGCOL, NUMBERCOL from TABLE");
while rset.next()
{
   //get the date data
   java.sql.Date date = rset.getDate(1);

   // get the streaming data
   InputStream is = rset.getAsciiStream(2);

   // Open a file to store the gif data
   FileOutputStream file = new FileOutputStream ("ascii.dat");

   // Loop, reading from the ascii stream and
   // write to the file
   int chunk;
   while ((chunk = is.read ()) != -1)
      file.write(chunk);
   // Close the file
   file.close();

   //get the number column data
   int n = rset.getInt(3);
}
```

The incoming data for each row has the following shape:

```
<a date><the characters of the long column><a number>
```

As you process each row of the iterator, you must complete any processing of the stream column before reading the number column.

An exception to this behavior is LOB data, which is also transferred between server and client as a Java stream. For more information on how the driver treats LOB data, see "Streaming LOBs and External Files" on page 4-21.

Bypassing Streaming Data Columns

There might be situations where you want to avoid reading a column that contains streaming data. If you do not want to read the data for the streaming column, then call the `close()` method of the stream object. This method discards the stream data and allows the driver to continue reading data for all the non-streaming columns that follow the stream. Even though you are intentionally discarding the stream, it is good programming practice to call the columns in SELECT-list order.

In the following example, the stream data in the `LONG` column is discarded and the data from only the `DATE` and `NUMBER` column is recovered:

```
ResultSet rset = stmt.executeQuery
        ("select DATECOL, LONGCOL, NUMBERCOL from TABLE");

while rset.next()
{
   //get the date
   java.sql.Date date = rset.getDate(1);

   // access the stream data and discard it with close()
   InputStream is = rset.getAsciiStream(2);
```

```
    is.close();

    // get the number column data
    int n = rset.getInt(3);
}
```

Streaming LOBs and External Files

The term *large object* (LOB) refers to a data item that is too large to be stored directly in a database table. Instead, a locator is stored in the database table and points to the location of the actual data. External files (binary files, or BFILEs) are managed similarly. The JDBC drivers can support these types through the use of streams:

- BLOBs (unstructured binary data)
- CLOBs (character data)
- BFILEs (external files)

LOBs and BFILEs behave differently from the other types of streaming data described in this chapter. The driver transfers data between server and client as a Java stream. However, unlike most Java streams, a locator representing the data is stored in the table. Thus, you can access the data at any time during the life of the connection.

Streaming BLOBs and CLOBs

When a query selects one or more `CLOB` or `BLOB` columns, the JDBC driver transfers to the client the data pointed to by the locator. The driver performs the transfer as a Java stream. To manipulate CLOB or BLOB data from JDBC, use methods in the Oracle extension classes `oracle.sql.BLOB` and `oracle.sql.CLOB`. These classes provide functionality such as reading from the CLOB or BLOB into an input stream, writing from an output stream into a CLOB or BLOB, determining the length of a CLOB or BLOB, and closing a CLOB or BLOB.

For a complete discussion of how to use streaming CLOB and BLOB data, see "Reading and Writing BLOB and CLOB Data" on page 14-4. CLOB and BLOB data may also be streamed with the same mechanism as for LONG and LONG RAW. See "Shortcuts For Inserting and Retrieving CLOB Data" on page 14-12.

Streaming BFILEs

An external file, or BFILE, is used to store a locator to a file outside the database, stored somewhere on the filesystem of the data server. The locator points to the actual location of the file.

When a query selects one or more `BFILE` columns, the JDBC driver transfers to the client the file pointed to by the locator. The transfer is performed in a Java stream. To manipulate BFILE data from JDBC, use methods in the Oracle extension class `oracle.sql.BFILE`. This class provides functionality such as reading from the BFILE into an input stream, writing from an output stream into a BFILE, determining the length of a BFILE, and closing a BFILE.

For a complete discussion of how to use streaming BFILE data, see "Reading BFILE Data" on page 14-16.

Closing a Stream

You can discard the data from a stream at any time by calling the stream's `close()` method. You can also close and discard the stream by closing its result set or connection object. You can find more information about the `close()` method for data

streams in "Bypassing Streaming Data Columns" on page 4-20. For information on how to avoid closing a stream and discarding its data by accident, see "Streaming Data Precautions" on page 4-22.

Notes and Precautions on Streams

This section discusses several noteworthy and cautionary issues regarding the use of streams:

- Streaming Data Precautions
- Using Streams to Avoid Limits on setBytes() and setString()
- Streaming and Row Prefetching

Streaming Data Precautions

This section describes some of the precautions you must take to ensure that you do not accidentally discard or lose your stream data. The drivers automatically discard stream data if you perform any JDBC operation that communicates with the database, other than reading the current stream. Two common precautions are described:

- Use the stream data after you access it.

  To recover the data from a column containing a data stream, it is not enough to `get` the column; you must immediately process its contents. Otherwise, the contents will be discarded when you get the next column.

- Call the stream column in SELECT-list order.

  If your query selects multiple columns, the database sends each row as a set of bytes representing the columns in the `SELECT` order. If one of the columns contains stream data, the database sends the entire data stream before proceeding to the next column.

  If you do not use the SELECT-list order to access data, then you can lose the stream data. That is, if you bypass the stream data column and access data in a column that follows it, the stream data will be lost. For example, if you try to access the data for the `NUMBER` column *before* reading the data from the stream data column, the JDBC driver first reads then discards the streaming data automatically. This can be very inefficient if the `LONG` column contains a large amount of data.

  If you try to access the `LONG` column later in the program, the data will not be available and the driver will return a "`Stream Closed`" error.

The second point is illustrated in the following example:

```
ResultSet rset = stmt.executeQuery
        ("select DATECOL, LONGCOL, NUMBERCOL from TABLE");
while rset.next()
{
   int n = rset.getInt(3);  // This discards the streaming data
   InputStream is = rset.getAsciiStream(2);
                            // Raises an error: stream closed.
}
```

If you get the stream but do not use it *before* you get the `NUMBER` column, the stream still closes automatically:

```
ResultSet rset = stmt.executeQuery
                 ("select DATECOL, LONGCOL, NUMBERCOL from TABLE");
while rset.next()
{
   InputStream is = rset.getAsciiStream(2); // Get the stream
   int n = rset.getInt(3);
   // Discards streaming data and closes the stream
}
int c = is.read(); // c is -1: no more characters to read-stream closed
```

Using Streams to Avoid Limits on setBytes() and setString()

There is a limit on the maximum size of the array which can be bound using the `PreparedStatement` class `setBytes()` method, and on the size of the string which can be bound using the `setString()` method.

Above the limits, which depend on the version of the server you use, you should use `setBinaryStream()` or `setCharacterStream()` instead.

Table 4–5 Bind-Size Limitations By

Database Version	maximum setBytes() (equals maximum RAW size)	maximum setString() (equals maximum VARCHAR2 size)
Oracle8 and later	2000	4000
Oracle7	255	2000

Note: This discussion applies to binds in SQL, not PL/SQL. If you use `setBinaryStream()` in PL/SQL, the maximum array size is 32 Kbytes -7.

Streaming and Row Prefetching

If the JDBC driver encounters a column containing a data stream, row prefetching is set back to 1.

Row prefetching is an Oracle performance enhancement that allows multiple rows of data to be retrieved with each trip to the database. See "Oracle Row Prefetching" on page 22-15.

Stored Procedure Calls in JDBC Programs

This section describes how the Oracle JDBC drivers support the following kinds of stored procedures:

- PL/SQL Stored Procedures
- Java Stored Procedures

PL/SQL Stored Procedures

Oracle JDBC drivers support execution of PL/SQL stored procedures and anonymous blocks. They support both SQL92 escape syntax and Oracle PL/SQL block syntax. The following PL/SQL calls would work with any Oracle JDBC driver:

```
// SQL92 syntax
CallableStatement cs1 = conn.prepareCall
                       ( "{call proc (?,?)}" ) ; // stored proc
CallableStatement cs2 = conn.prepareCall
                       ( "{? = call func (?,?)}" ) ; // stored func
// Oracle PL/SQL block syntax
CallableStatement cs3 = conn.prepareCall
                       ( "begin proc (?,?); end;" ) ; // stored proc
CallableStatement cs4 = conn.prepareCall
                       ( "begin ? := func(?,?); end;" ) ; // stored func
```

As an example of using Oracle syntax, here is a PL/SQL code snippet that creates a stored function. The PL/SQL function gets a character sequence and concatenates a suffix to it:

```
create or replace function foo (val1 char)
return char as
begin
   return val1 || 'suffix';
end;
```

The function invocation in your JDBC program should look like:

```
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:oci:@<hoststring>");
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();

CallableStatement cs = conn.prepareCall ("begin ? := foo(?); end;");
cs.registerOutParameter(1,Types.CHAR);
cs.setString(2, "aa");
cs.executeUpdate();
String result = cs.getString(1);
```

Java Stored Procedures

You can use JDBC to invoke Java stored procedures through the SQL and PL/SQL engines. The syntax for calling Java stored procedures is the same as the syntax for calling PL/SQL stored procedures, presuming they have been properly "published" (that is, have had call specifications written to publish them to the Oracle data dictionary).

Processing SQL Exceptions

To handle error conditions, the Oracle JDBC drivers throws SQL exceptions, producing instances of class `java.sql.SQLException` or a subclass. Errors can originate either in the JDBC driver or in the database (RDBMS) itself. Resulting messages describe the error and identify the method that threw the error. Additional run-time information can also be appended.

Basic exception-handling can include retrieving the error message, retrieving the error code, retrieving the SQL state, and printing the stack trace. The `SQLException` class includes functionality to retrieve all of this information, where available.

Errors originating in the JDBC driver are listed with their `ORA` numbers in Appendix A, "JDBC Error Messages".

Errors originating in the RDBMS are documented in the *Oracle Database Error Messages* reference.

Retrieving Error Information

You can retrieve basic error information with these `SQLException` methods:

- `getMessage()`

  For errors originating in the JDBC driver, this method returns the error message with no prefix. For errors originating in the RDBMS, it returns the error message prefixed with the corresponding `ORA` number.

- `getErrorCode()`

  For errors originating in either the JDBC driver or the RDBMS, this method returns the five-digit `ORA` number.

- `getSQLState()`

  For errors originating in the JDBC driver, this returns no useful information. For errors originating in the RDBMS, this method returns a five-digit code indicating the SQL state. Your code should be prepared to handle null data.

The following example prints output from a `getMessage()` call.

```
catch(SQLException e)
{
   System.out.println("exception: " + e.getMessage());
}
```

This would print output such as the following for an error originating in the JDBC driver:

```
exception: Invalid column type
```

(There is no `ORA` number message prefix for errors originating in the JDBC driver, although you can get the `ORA` number with a `getErrorCode()` call.)

> **Note:** Error message text is available in alternative languages and character sets supported by Oracle.

Printing the Stack Trace

The `SQLException` class provides the following method for printing a stack trace.

- `printStackTrace()`

  This method prints the stack trace of the throwable object to the standard error stream. You can also specify a `java.io.PrintStream` object or `java.io.PrintWriter` object for output.

The following code fragment illustrates how you can catch SQL exceptions and print the stack trace.

```
try { <some code> }
catch(SQLException e) { e.printStackTrace (); }
```

To illustrate how the JDBC drivers handle errors, assume the following code uses an incorrect column index:

```
// Iterate through the result and print the employee names
// of the code

try {
  while (rset.next ())
      System.out.println (rset.getString (5));  // incorrect column index
}
catch(SQLException e) { e.printStackTrace (); }
```

Assuming the column index is incorrect, executing the program would produce the following error text:

```
java.sql.SQLException: Invalid column index
at oracle.jdbc.dbaccess.DBError.check_error(DBError.java:235)
at oracle.jdbc.OracleStatement.prepare_for_new_get(OracleStatement.java:1560)
at oracle.jdbc.OracleStatement.getStringValue(OracleStatement.java:1653)
at oracle.jdbc.OracleResultSet.getString(OracleResultSet.java:175)
at Employee.main(Employee.java:41)
```

5

JDBC Standards Support

Oracle JDBC supports several different versions of JDBC, including JDBC 2.0 and 3.0.

This chapter provides an overview of JDBC 2.0 and 3.0 support in the Oracle JDBC drivers. The following topics are discussed:

Introduction

The Oracle JDBC drivers provide substantial support for the JDBC 3.0 specification. Oracle makes supported JDBC 3.0 features are available in JDK1.2 through Oracle extensions. The following changes have been made as part of this support:

- The `oracle.jdbc2` package has been removed.
- JDK1.1.x is no longer supported.

The Oracle JDBC drivers support most JDBC 3.0 features, including:

- Using global and distributed transactions on the same connection (see "Oracle XA Packages" on page 9-4)
- Transaction savepoints (see "Transaction Savepoints" on page 5-4)
- Re-use of prepared statements by connection pools (also known as statement caching; see Chapter 6, "Statement Caching")
- Full support for JDK1.4 (see "JDBC 3.0 Support: JDK 1.4 and Previous Releases" in this chapter)

All of these features are provided in the packages `oracle.jdbc` and `oracle.sql`. These packages support all JDK releases from 1.2 through 1.4; JDBC 3.0 features that depend on JDK1.4 are made available to earlier JDK versions through Oracle extensions.

JDBC 2.0 Support: JDK 1.2.x and Higher Versions

Standard JDBC 2.0 features are supported for all JDK versions at 1.2 or higher. There are three areas to consider:

- datatype support—such as for objects, arrays, and LOBs—which is handled through the standard `java.sql` package
- standard feature support—such as result set enhancements and update batching—which is handled through standard objects such as `Connection`, `ResultSet`, and `PreparedStatement` under JDK 1.2.x and higher
- extended feature support—features of the JDBC 2.0 Optional Package (also known as the Standard Extension API), including datasources, connection pooling, and distributed transactions—under JDK 1.2. and higher

This section also discusses performance enhancements available under JDBC 2.0—update batching and fetch size—that are also still available as Oracle extensions, then concludes with a brief discussion about migration from JDK 1.1.x to JDK 1.2.x.

Datatype Support

Oracle JDBC fully supports JDK 1.2.x, which includes standard JDBC 2.0 functionality through implementation of interfaces in the standard `java.sql` package. These interfaces are implemented as appropriate by classes in the `oracle.sql` and `oracle.jdbc` packages.

Standard Feature Support

In a JDK 1.2.x environment (using the JDBC classes in `classes12.jar`), JDBC 2.0 features such as scrollable result sets, updatable result sets, and update batching are supported through methods specified by standard JDBC 2.0 interfaces.

Extended Feature Support

Features of the JDBC 2.0 Optional Package (also known as the Standard Extension API), including datasources, connection pooling, and distributed transactions, are supported in a JDK 1.2.x or later environment.

The standard `javax.sql` package and classes that implement its interfaces are included in the JDBC `classes12.jar` file.

Standard versus Oracle Performance Enhancement APIs

There are two performance enhancements available under JDBC 2.0, which had previously been available as Oracle extensions:

- update batching
- fetch size / row prefetching

In each case, you have the option of using the standard model or the Oracle model. Do not, however, try to mix usage of the standard model and Oracle model within a single application for either of these features.

For more information, see the following sections:

- "Update Batching" on page 22-1
- "Fetch Size" on page 17-15
- "Oracle Row Prefetching" on page 22-15

Migration from JDK 1.1.x

The only migration requirements in upgrading from JDK 1.1.x are as follows:

- Remove your imports of the `oracle.jdbc2` package
- Replace any direct references to `oracle.jdbc2.*` interfaces with references to the standard `java.sql.*` interfaces.
- Type map objects (for mapping SQL structured objects to Java types), which must extend the `java.util.Dictionary` class under JDK 1.1.x, must implement the `java.util.Map` interface under JDK 1.2.x. Note, however, that the class `java.util.Hashtable` satisfies either requirement. If you used `Hashtable` objects for your type maps under JDK 1.1.x, then no change is necessary. For more information, see "Creating a Type Map Object and Defining Mappings for a SQLData Implementation" on page 13-9.

If these points do not apply to your code, then you do not need to make any code changes or recompile to run under JDK 1.2 and higher releases.

JDBC 3.0 Support: JDK 1.4 and Previous Releases

This release adds or extends the following interfaces and classes.

Table 5–1 JDBC 3.0 Feature Support

New feature	JDK1.4 implementation	Pre-JDK1.4 implementation
Savepoints (new class)	`java.sql.Savepoint`	`oracle.jdbc.OracleSavepoint`
Savepoints (connection extensions)	`java.sql.connection`	`oracle.jdbc.OracleConnection`
Querying parameter capacities (new class)	`java.sql.ParameterMetaData`	`oracle.jdbc.OracleParameterMetaData`
Querying parameter capacities (interface change)	Not applicable	`oracle.jdbc.OraclePreparedStatement`
Resource adapters	`oracle.jdbc.connector`	`oracle.jdbc.connector`
WebRowSet	`oracle.jdbc.rowset.OracleWebRowSet`	`oracle.jdbc.rowset.OracleWebRowSet`
LOB modification	Not applicable	`oracle.sql.BLOB` `oracle.sql.CLOB`

Overview of Supported JDBC 3.0 Features

Table 5–2 lists the JDBC 3.0 features supported at this release and gives references to a detailed discussion of each feature.

Table 5–2 Key Areas of JDBC 3.0 Functionality

Feature	Comments and References
Transaction savepoints	See "Transaction Savepoints" on page 5-4 for information.
Connection sharing	Re-use of prepared statements by connection pools (see Chapter 6, "Statement Caching".
Switching between local and global transactions	See "Switching Between Global and Local Transactions" on page 9-4.
LOB modification	See "JDBC 3.0 LOB Interface Methods" on page 5-7.
Named SQL parameters	See "Interface oracle.jdbc.OracleCallableStatement" on page 10-15 and "Interface oracle.jdbc.OraclePreparedStatement" on page 10-14.
WebRowSet	See Chapter 18, "Row Set".

Unsupported JDBC 3.0 Features

The following JDBC 3.0 features are not supported at this release:

- Retrieval of auto-generated keys
- `ResultSet` holdability
- Multiple open `ResultSets`

Transaction Savepoints

The JDBC 3.0 specification supports *savepoints*, which offer finer demarcation within transactions. Applications can set a savepoint within a transaction and then roll back (but **not** commit) all work done after the savepoint. Savepoints relax the atomicity property of transactions. A transaction with a savepoint is atomic in the sense that it appears to be a single unit outside the context of the transaction, but code operating within the transaction can preserve partial states.

Note: Savepoints are supported for local transactions only. Specifying a savepoint within a global transaction causes `SQLException` to be thrown.

JDK1.4 specifies a standard savepoint API. Oracle JDBC provides two different savepoint interfaces: one (`java.sql.Savepoint`) for JDK1.4 and one (`oracle.jdbc.OracleSavepoint`) that works across all supported JDK versions. JDK1.4 adds savepoint-related APIs to `java.sql.Connection`; the Oracle JDK version-independent interface `oracle.jdbc.OracleConnection` provides equivalent functionality.

Creating a Savepoint

You create a savepoint using either `Connection.setSavepoint()`, which returns a `java.sql.Savepoint` instance, or

`OracleConnection.oracleSetSavepoint()`, which returns an `oracle.jdbc.OracleSavepoint` instance.

A savepoint is either named or unnamed. You specify a savepoint's name by supplying a string to the `setSavepoint()` method; if you do not specify a name, the savepoint is assigned an integer ID. You retrieve a name using `getSavepointName()`; you retrieve an ID using `getSavepointId()`.

Note: Attempting to retrieve a name from an unnamed savepoint or attempting to retrieve an ID from a named savepoint throws an `SQLException`.

Rolling back to a Savepoint

You roll back to a savepoint using `Connection.rollback(Savepoint svpt)` or `OracleConnection.oracleRollback(OracleSavepoint svpt)`. If you try to roll back to a savepoint that has been released, `SQLException` is thrown.

Releasing a Savepoint

You remove a savepoint using `Connection.releaseSavepoint(Savepoint svpt)` or `OracleConnection.oracleReleaseSavepoint(OracleSavepoint svpt)`.

Note: As of 10*g* Release 1 (10.1), `releaseSavepoint()` and `oracleReleaseSavepoint()` are not supported; if you invoke either message, `SQLException` is thrown with the message "Unsupported feature".

Checking Savepoint Support

You query whether savepoints are supported by your database by calling `oracle.jdbc.OracleDatabaseMetaData.supportsSavepoints()`, which returns `true` if savepoints are available, `false` otherwise.

Savepoint Notes

- After a savepoint has been released, attempting to reference it in a rollback operation will cause an `SQLException` to be thrown.
- When a transaction is committed or rolled back, all savepoints created in that transaction are automatically released and become invalid.
- Rolling a transaction back to a savepoint automatically releases and makes invalid any savepoints created after the savepoint in question.

Savepoint Interfaces

The following methods are used to get information from savepoints. These methods are defined within both the `java.sql.Connection` and `oracle.jdbc.OracleSavepoint` interfaces:

public int getSavepointId() throws SQLException;

Return the savepoint ID for an unnamed savepoint.

Exceptions:

- `SQLException`: Thrown if `self` is a named savepoint.

public String getSavepointName() throws SQLException;

Return the name of a named savepoint.

Exceptions:

- `SQLException`: Thrown if `self` is an unnamed savepoint.

These methods are defined within the `java.sql.Connection` interface:

public Savepoint setSavepoint() throws SQLException;

Create an unnamed savepoint.

Exceptions:

- `SQLException`: Thrown on database error, or if Connection is in auto-commit mode or participating in a global transaction.

publicSavepoint setSavepoint(String name) throws SQLException;

Create a named savepoint. If a `Savepoint` by this name already exists, this instance replaces it.

Exceptions:

- `SQLException`: Thrown on database error or if Connection is in auto-commit mode or participating in a global transaction.

public void rollback(Savepoint savepoint) throws SQLException;

Remove specified Savepoint from current transaction. Any references to the savepoint after it is removed cause an `SQLException` to be thrown.

Exceptions:

- `SQLException`: Thrown on database error or if Connection is in auto-commit mode or participating in a global transaction.

public void releaseSavepoint(Savepoint savepoint) throws SQLException;

Not supported at this release. Always throws `SQLException`.

Pre-JDK1.4 Savepoint Support

These methods are defined within the `oracle.jdbc.OracleConnection` interface; except for using `OracleSavepoint` in the signatures, they are identical to the methods above.

public OracleSavepoint oracleSetSavepoint() throws SQLException;

public OracleSavepoint oracleSetSavepoint(String name) throws SQLException;

public void oracleRollback(OracleSavepoint savepoint) throws SQLException;

public void oracleReleaseSavepoint(OracleSavepoint savepoint) throws SQLException;

JDBC 3.0 LOB Interface Methods

Before 10*g* Release 1 (10.1), Oracle provided proprietary interfaces for modification of LOB data. JDBC 3.0 adds methods for these operations. In 9*i*R2, the JDBC 3.0 methods were present in `ojdbc14.jar` but were not functional. The JDBC 3.0 standard LOB methods differ slightly in name and function from the Oracle proprietary ones. In 10*g* Release 1 (10.1), the JDBC 3.0 standard methods are implemented in both `ojdbc14.jar` and `classes12.jar`. In order to use these methods with JDK1.2 or 1.3, LOB variables must be typed as (or cast to) `oracle.sql.BLOB` or `oracle.sql.CLOB` as appropriate. With JDK1.4, LOB variables may be typed as `java.sql.Blob` or `java.sql.Clob`. The Oracle proprietary methods are marked as deprecated and will be removed in a future release.

Table 5–3 and Table 5–4 show the conversions between Oracle proprietary methods and JDBC 3.0 standard methods.

Table 5–3 BLOB Method Equivalents

Oracle Proprietary Method	JDBC 3.0 Standard Method Replacement
`putBytes(long pos, byte [] bytes)`	`setBytes(long pos, byte[] bytes)`
`putBytes(long pos, byte [] bytes, int length)`	`setBytes(long pos, byte[] bytes, int offset, int len)`
`getBinaryOutputStream(long pos)`	`setBinaryStream(long pos)`
`trim (long len)`	`truncate(long len)`

Table 5–4 CLOB Method Equivalents

Oracle Proprietary Method	JDBC 3.0 Standard Method Replacement
`putString(long pos, String str)`	`setString(long pos, String str)`
not applicable	`setString(long pos, String str, int offset, int len)`
`getAsciiOutputStream(long pos)`	`setAsciiStream(long pos)`
`getCharacterOutputStream(long pos)`	`setCharacterStream(long pos)`
`trim (long len)`	`truncate(long len)`

6

Statement Caching

This chapter describes the benefits and use of statement caching, an Oracle JDBC extension.

This following topics are discussed:

- About Statement Caching
- Using Statement Caching

> **Note:** Starting at release 9.2, Oracle JDBC provides a new statement cache interface and implementation, replacing the API supported at Release 9.1.0. The previous API is now deprecated.

About Statement Caching

Statement caching improves performance by caching executable statements that are used repeatedly, such as in a loop or in a method that is called repeatedly. JDBC 3.0 defines a statement-caching interface.

Statement caching can:

- Prevent the overhead of repeated cursor creation
- Prevent repeated statement parsing and creation

Basics of Statement Caching

Use a statement cache to cache statements associated with a particular physical connection. For a simple connection, the cache is associated with an `OracleConnection` object. For a pooled connection, the cache is associated with an `OraclePooledConnection` or `PooledConnection` object. The `OracleConnection` and `OraclePooledConnection` objects include methods to enable statement caching. When you enable statement caching, a statement object is cached when you call the "close" methods.

Because each physical connection has its own cache, multiple caches can exist if you enable statement caching for multiple physical connections. When you enable statement caching on a pooled connection, all the logical connections will use the *same* cache. If you try to enable statement caching on a logical connection of a pooled connection, this will throw an exception.

There are two types of statement caching: implicit and explicit. Each type of statement cache can be enabled or disabled independent of the other: you can have either, neither, or both in effect. Both types of statement caching share a cache.

Implicit Statement Caching

When you enable *implicit statement caching*, JDBC automatically caches the prepared or callable statement when you call the `close()` method of this statement object. The prepared and callable statements are cached and retrieved using standard connection object and statement object methods.

Plain statements are not implicitly cached, because implicit statement caching uses a SQL string as a key, and plain statements are created without a SQL string. Therefore, implicit statement caching applies only to the `OraclePreparedStatement` and `OracleCallableStatement` objects, which are created with a SQL string. When one of these statements is created, the JDBC driver automatically searches the cache for a matching statement. The match criteria are the following:

- The SQL string in the statement must be identical (case-sensitive) to one in the cache.
- The statement type must be the same (prepared or callable).
- The scrollable type of result sets produced by the statement must be the same (forward-only or scrollable). You can determine the scrollability when you create the statement. (See "Specifying Result Set Scrollability and Updatability" on page 17-5 for complete details.)

If a match is found during the cache search, the cached statement is returned. If a match is not found, then a new statement is created and returned. The new statement, along with its cursor and state, are cached when you call the `close()` method of the statement object.

When a cached `OraclePreparedStatement` or `OracleCallableStatement` object is retrieved, the state and data information are automatically re-initialized and reset to default values, while metadata is saved. The Least Recently Used (LRU) scheme performs the statement cache operation.

Note: The JDBC driver does not clear metadata. However, although metadata is saved for performance reasons, it has no semantic impact. A statement that comes from the implicit cache appears as if it were newly created.

You can prevent a particular statement from being implicitly cached; see "Disabling Implicit Statement Caching for a Particular Statement" on page 6-6.

Explicit Statement Caching

Explicit statement caching enables you to cache and retrieve selected prepared, callable, and plain statements. Explicit statement caching relies on a *key*, an arbitrary Java string that you provide.

Because explicit statement caching retains statement data and state as well as metadata, it has a performance edge over implicit statement caching, which retains only metadata. However, because explicit statement caching saves all three types of information for re-use, you must be cautious when using this type of caching—you may not be aware of what was retained for data and state in the previous statement.

With implicit statement caching, you take no special action to retrieve statements from a cache. Instead, whenever you call `prepareStatement()` or `prepareCall()`, JDBC automatically checks the cache for a matching statement and returns it if found.

With explicit statement caching, you use specialized Oracle "WithKey" methods to cache and retrieve statement objects.

Implicit statement caching uses the SQL string of a prepared or callable statement as the key, requiring no action on your part. Explicit statement caching requires you to provide a Java string, which it uses as the key.

During implicit statement caching, if the JDBC driver cannot find a statement in cache, it will automatically create one. During explicit statement caching, if the JDBC driver cannot find a matching statement in cache, it will return a `null` value.

Table 6–1 compares the different methods employed in implicit and explicit statement caching.

Table 6–1 Comparing Methods Used in Statement Caching

	Allocate	Insert Into Cache	Retrieve From Cache
Implicit	`prepareStatement()` `prepareCall()`	`close()`	`prepareStatement()` `prepareCall()`

Explicit	`createStatement()`
	`prepareStatement()`
	`prepareCall()`
		`closeWithKey()`	`getStatementWithKey()`
			`getCallWithKey()`

Using Statement Caching

This section discusses the following topics:

- Enabling and Disabling Statement Caching
- Checking for Statement Creation Status
- Physically Closing a Cached Statement
- Using Implicit Statement Caching
- Using Explicit Statement Caching

Enabling and Disabling Statement Caching

Implicit and explicit statement caching can be enabled or disabled independent of one other: you can have either, neither, or both in effect.

Enabling and Disabling Implicit Statement Caching

Enable implicit statement caching in one of two ways:

- Invoking `setImplicitCachingEnabled(true)` on the connection
- Invoking `OracleDataSource.getConnection()` with the `ImplicitCachingEnabled` property set to `true`; you set `ImplicitCachingEnabled` by calling `OracleDataSource.setImplicitCachingEnabled(true)`

Disable implicit statement caching by invoking `setImplicitCachingEnabled(false)` on the connection or by setting the `ImplicitCachingEnabled` property to `false`.

To determine whether implicit caching is enabled, call `getImplicitCachingEnabled()`, which returns `true` if implicit caching is enabled, `false` otherwise.

Enabling and Disabling Explicit Statement Caching

To enable explicit statement caching you must first set the application cache size. You set the cache size in one of two ways:

- invoking `OracleConnection.setStatementCacheSize()` on the physical connection
- invoking `OracleDatasource.setMaxStatements()`

In either case, the argument you supply is the maximum number of statements in the cache; an argument of 0 specifies no caching. To check the cache size, use the `getStatementCacheSize()` method.

```
System.out.println("Stmt Cache size is " +
   ((OracleConnection)conn).getStatementCacheSize());
```

Enable explicit statement caching by invoking `setExplicitCachingEnabled(true)` on the connection.

To determine whether explicit caching is enabled, call `getExplicitCachingEnabled()`, which returns `true` if implicit caching is enabled, `false` otherwise.

Notes:

- You enable implicit and explicit caching for a particular physical connection independently. Therefore, it is possible to do statement caching both implicitly and explicitly during the same session.
- Implicit and explicit statement caching share the *same* cache. Remember this when you set the statement cache size.

The following code specifies a cache size of ten statements:

```
((OracleConnection)conn).setStatementCacheSize(10);
```

Disable explicit statement caching by calling `setExplicitCachingEnabled(false)`. Disabling caching or closing the cache purges the cache. The following example disables explicit statement caching:

```
((OracleConnection)conn).setExplicitCachingEnabled(false);
```

Checking for Statement Creation Status

By calling the `creationState()` method of a statement object, you can determine if a statement was newly created or if it was retrieved from cache on an implicit or explicit lookup. The `creationState()` method returns the following integer values for plain, prepared, and callable statements:

> **Note:** The `creationState()` method is now deprecated; this section is included for backward compatibility only.

- `NEW` - The statement was newly created.
- `IMPLICIT` - The statement was retrieved on an implicit statement lookup.
- `EXPLICIT` - The statement was retrieved on an explicit statement lookup.

For example, the JDBC driver returns `OracleStatement.EXPLICIT` for an explicitly cached statement. The following code checks the statement creation status for `stmt`:

```
int state = ((OracleStatement)stmt).creationState();
   ...(process state)
```

Physically Closing a Cached Statement

With implicit statement caching enabled, you cannot truly physically close statements manually. The `close()` method of a statement object caches the statement instead of closing it. The statement is physically closed automatically under one of three conditions: (1) when the associated connection is closed, (2) when the cache reaches its size limit and the least recently used statement object is preempted from cache by the LRU scheme, or (3) if you call the `close()` method on a statement for which statement caching is disabled. (See "Disabling Implicit Statement Caching for a Particular Statement" on page 6-6 for more details.)

Using Implicit Statement Caching

Once you enable implicit statement caching, by default all prepared and callable statements are automatically cached. Implicit statement caching includes the following steps:

1. Enable implicit statement caching as described in "Enabling and Disabling Implicit Statement Caching" on page 6-4.
2. Allocate a statement using one of the standard methods.
3. (Optional) Disable implicit statement caching for any particular statement you do not want to cache.
4. Cache the statement using the `close()` method.
5. Retrieve the implicitly cached statement by calling the appropriate standard "prepare" method.

The following sections explain the implicit statement caching steps in more detail.

Allocating a Statement for Implicit Caching

To allocate a statement for implicit statement caching, use either the `prepareStatement()` or `prepareCall()` method as you would normally. (These are methods of the connection object.)

The following code allocates a new statement object called `pstmt`:

```
PreparedStatement pstmt = conn.prepareStatement
   ("UPDATE emp SET ename = ? WHERE rowid = ?");
```

Disabling Implicit Statement Caching for a Particular Statement

With implicit statement caching enabled for a connection, by default all callable and prepared statements of that connection are automatically cached. To prevent a particular callable or prepared statement from being implicitly cached, use the `setDisableStatementCaching()` method of the statement object. To help you manage cache space, you can call the `setDisableStatementCaching()` method on any infrequently used statement.

The following code disables implicit statement caching for `pstmt`:

```
PreparedStatement pstmt = conn.prepareStatement("SELECT 1 from DUAL");
((OraclePreparedStatement)pstmt).setDisableStmtCaching(true);
pstmt.close ();
```

Implicitly Caching a Statement

To cache an allocated statement, call the `close()` method of the statement object. When you call the `close()` method on an `OraclePreparedStatement` or `OracleCallableStatement` object, the JDBC driver automatically puts this statement in cache, unless you have disabled caching for this statement.

The following code caches the `pstmt` statement:

```
((OraclePreparedStatement)pstmt).close ();
```

Retrieving an Implicitly Cached Statement

To retrieve an implicitly cached statement, call either the `prepareStatement()` or `prepareCall()` method, depending on the statement type.

The following code retrieves `pstmt` from cache using the `prepareStatement()` method:

```
pstmt = conn.prepareStatement ("UPDATE emp SET ename = ? WHERE rowid = ?");
```

If you call the `creationState()` method on the `pstmt` statement object, the method returns `IMPLICIT`. If the `pstmt` statement object was not in cache, then the `creationState()` method returns `NEW` to indicate a new statement was recently created by the JDBC driver.

Table 6–2 describes the methods used to allocate statements and retrieve implicitly cached statements.

Table 6–2 Methods Used in Statement Allocation and Implicit Statement Caching

Method	Functionality for Implicit Statement Caching
`prepareStatement()`	Triggers a cache search that either finds and returns the desired cached `OraclePreparedStatement` object or allocates a new `OraclePreparedStatement` object if a match is not found
`prepareCall()`	Triggers a cache search that either finds and returns the desired cached `OracleCallableStatement` object or allocates a new `OracleCallableStatement` object if a match is not found

Using Explicit Statement Caching

A plain, prepared, or callable statement can be explicitly cached when you enable explicit statement caching. Explicit statement caching includes the following steps:

1. Enable explicit statement caching as described in "Enabling and Disabling Explicit Statement Caching" on page 6-4.
2. Allocate a statement using one of the standard methods.
3. Explicitly cache the statement by closing it with a key, using the `closeWithKey()` method.
4. Retrieve the explicitly cached statement by calling the appropriate Oracle "WithKey" method, specifying the appropriate key.
5. Re-cache an open, explicitly cached statement by closing it again with the `closeWithKey()` method. Each time a cached statement is closed, it is re-cached with its key.

The following sections explain the explicit statement caching steps in more detail.

Allocating a Statement for Explicit Caching

To allocate a statement for explicit statement caching, use either the `createStatement()`, `prepareStatement()`, or `prepareCall()` method as you would normally. (These are methods of the connection object.)

The following code allocates a new statement object called `pstmt`:

```
PreparedStatement pstmt =
   conn.prepareStatement ("UPDATE emp SET ename = ? WHERE rowid = ?");
```

Explicitly Caching a Statement

To explicitly cache an allocated statement, call the `closeWithKey()` method of the statement object, specifying a key. The key is an arbitrary Java string that you provide. The `closeWithKey()` method caches a statement as is. This means the data, state, and metadata are retained and not cleared.

The following code caches the `pstmt` statement with the key `"mykey"`:

```
((OraclePreparedStatement)pstmt).closeWithKey ("mykey");
```

Retrieving an Explicitly Cached Statement

To recall an explicitly cached statement, call either the `getStatementWithKey()` or `getCallWithKey()` methods depending on the statement type.

If you retrieve a statement with a specified key, the JDBC driver searches the cache for the statement, based on the specified key. If a match is found, the matching statement is returned, along with its state, data, and metadata. This information is returned as it was when last closed. If a match is not found, the JDBC driver returns `null`.

The following code recalls `pstmt` from cache using the `"mykey"` key with the `getStatementWithKey()` method. Recall that the `pstmt` statement object was cached with the `"mykey"` key.

```
pstmt = ((OracleConnection)conn).getStatementWithKey ("mykey");
```

If you call the `creationState()` method on the `pstmt` statement object, the method returns `EXPLICIT`.

> **Important:** When you retrieve an explicitly cached statement, be sure to use the method that is appropriate for your statement type when specifying the key. For example, if you used the `prepareStatement()` method to allocate a statement, then use the `getStatementWithKey()` method to retrieve that statement from cache. The JDBC driver cannot verify the type of statement it is returning.

Table 6–3 describes the methods used to retrieve explicitly cached statements.

Table 6–3 Methods Used to Retrieve Explicitly Cached Statements

Method	Functionality for Explicit Statement Caching
`getStatementWithKey()`	specifies the key needed to retrieve a prepared statement from cache
`getCallWithKey()`	specifies the key needed to retrieve a callable statement from cache

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Implicit Connection Caching

Connection caching, generally implemented in the middle tier, is a means of keeping and using caches of physical database connections.

> **Note:** The previous cache architecture, based on `OracleConnectionCache` and `OracleConnectionCacheImpl`, is deprecated. We recommend that you take advantage of the new architecture, which is more powerful and offers better performance.

The Implicit Connection Cache is an improved JDBC 3.0-compliant connection cache implementation for `DataSource`. Java and J2EE applications benefit from transparent access to the cache, support for multiple users, and the ability to request connections based on user-defined profiles.

An application turns the implicit connection cache on by invoking `setConnectionCachingEnabled(true)` on an `OracleDataSource`. After implicit caching is turned on, the first connection request to the `OracleDataSource` transparently creates a connection cache. There is no need for application developers to write their own cache implementations.

This section is divided into the following topics:

> **Note:** The concept of connection caching is not relevant to the server-side internal driver, where you are simply using the default connection. Connection caching is only relevant to the client-side JDBC drivers.

The Implicit Connection Cache

The connection caching architecture has been redesigned so that caching is transparently integrated into the datasource architecture.

The connection cache uses the concept of *physical connections* and *logical connections*. Physical connections are the actual connections returned by the database; logical connections are wrappers used by the cache to manipulate physical connections. You can think of logical connections as handles. The caches always return logical connections, which implement all the same interfaces as physical connections.

The implicit connection cache offers:

- **Driver independence**. Both the Thin and OCI drivers support the Implicit Connection Cache.
- **Transparent access to the JDBC connection cache.** After an application turns implicit caching on, it uses the standard `OracleDataSource` APIs to get connections. With caching enabled, all connection requests are serviced from the connection cache.

  When an application invokes `OracleConnection.close()` to close the logical connection, the physical connection is returned to the cache.
- **Single cache per OracleDataSource instance.** When connection caching is turned on, each `OracleDataSource` has exactly one cache associated with it. All connections obtained through that datasource, no matter what username and password are used, are returned to the cache. When an application requests a connection from the datasource, the cache either returns an existing connection or creates a new connection with matching authentication information.

  Note: Caches cannot be shared between `DataSource` instances; there is a one-to-one mapping between a `DataSource` instance and a cache.

- **Heterogeneous usernames and passwords per cache.** Unlike in the previous cache implementation, all connections obtained through the same datasource are stored in a common cache, no matter what username and password the connection requests.
- **Support for JDBC 3.0 connection caching, including support for multiple users and the required cache properties.**
- **Property-based configuration.** Cache properties define the behavior of the cache. The supported properties set timeouts, the number of connections to be held in the cache, and so on. Using these properties, applications can reclaim and reuse abandoned connections. The implicit connection cache supports all the JDBC 3.0 connection cache properties.
- **OracleConnectionCacheManager.** The new class `OracleConnectionCacheManager` provides a rich set of administrative APIs applications can use to manage the connection cache. Using these APIs, applications can refresh stale connections. Each Virtual Machine has one distinguished instance of `OracleConnectionCacheManager`. Applications manage a cache through the single `OracleConnectionCacheManager` instance

  Note: The cache name is not a cache property and cannot be changed once the cache is created.

- **User-defined connection attributes.** The implicit connection cache supports user-defined connection attributes that can be used to determine which connections are retrieved from the cache. Connection attributes can be thought of as labels whose semantics are defined by the application, not by the caching mechanism.
- **Callback mechanism.** The implicit connection cache provides a mechanism for users to define cache behavior when a connection is returned to the cache, when handling abandoned connections, and when a connection is requested but none is available in the cache.

Using the Connection Cache

This section discusses how applications use the implicit connection cache.

Turning Caching On

An application turns the implicit connection cache on by invoking `OracleDataSource.setConnectionCachingEnabled(true)`. After implicit caching is turned on, the first connection request to the `OracleDataSource` transparently creates a connection cache.

Here is a simple example using the implicit connection cache.

Example 7–1 Using the Implicit Connection Cache

```
// Example to show binding of OracleDataSource to JNDI,
// then using implicit connection cache

import oracle.jdbc.pool.*; // import the pool package

Context ctx = new InitialContext(ht);
OracleDataSource ods = new OracleDataSource();

// Set DataSource properties
ods.setUser("Scott");
ods.setConnectionCachingEnabled(true);    // Turns on caching
ctx.bind("MyDS", ods);
// ...
// Retrieve DataSource from the InitialContext
ods =(OracleDataSource) ctx. lookup("MyDS");

// Transparently create cache and retrieve connection
conn = ods.getConnection();
// ...
conn.close();  // return connection to the cache
// ...
ods.close() // close datasource and clean up the cache
```

For details on the connection cache API, see the Javadoc for `OracleDataSource` and `OracleConnectionCacheManager`.

Opening a Connection

After you have turned connection caching on, whenever you retrieve a connection through an `OracleDataSource.getConnection()`, the JDBC drivers check to see if a connection is available in the cache.

The `getConnection()` method checks if there are any free physical connections in the cache that match the specified criteria. If a match is found, a logical connection is returned wrapping the physical connection. If no physical connection match is found, a new physical connection is created, wrapped in a logical connection, and returned.

There are four variations on `getConnection()`, two that make no reference to the connection cache, and two that specify which sorts of connections the cache may return. The non-cache-specific `getConnection()` methods behave as normal.

The connection-cache-specific variations are:

- `getConnection(java.util.Properties cachedConnectionAttributes)`—requests a database connection that matches the specified `cachedConnectionAttributes` (see "Other Properties" on page 7-9 for a discussion of connection attributes)
- `getConnection(java.lang.String user, java.lang.String passwd, java.util.Properties cachedConnectionAttributes)`—requests a database connection from the Implicit Connection Cache that matches the specified `user`, `passwd` and `cachedConnectionAttributes`

> **Note:** For a discussion of connection cache attributes, see "Connection Attributes" on page 7-5.

Setting Connection Cache Name

You can specify the connection cache's name by invoking `setConnectionCacheName()`.

Setting Connection Cache Properties

You can fine-tune the behavior of the Implicit Connection cache using the `setConnectionCacheProperties()` method to set various connection properties. These properties are documented in "Connection Cache Properties" on page 7-8.

> **Note:** Although these properties govern the behavior of the connection cache, they are set on the datasource, not on the connection or on the cache itself.

Closing A Connection

An application returns a connection to the cache by invoking `close()`. There are two variants on the close method: one with no arguments, and one that takes a connection attribute argument, discussed in "Setting Connection Attributes" on page 7-6.

> **Note:** The `close()` method is new at this release. Applications must close connections in order ensure that they are returned to the cache.

Implicit Connection Cache Example

Example 7–2 demonstrates creating a datasource, setting its caching and datasource properties, retrieving a connection, and closing that connection in order to return it to the cache.

Example 7–2 Connection Cache Example

```
import java.sql.*;
import javax.sql.*;
import java.util.*;
import javax.naming.*;
import javax.naming.spi.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.*;

...

    // create a DataSource
    OracleDataSource ods = new OracleDataSource();

    // set cache properties
    java.util.Properties prop = new java.util.Properties();
    prop.setProperty("MinLimit", "2");
    prop.setProperty("MaxLimit", "10");

    // set DataSource properties
    String url = "jdbc:oracle:oci8:@";
    ods.setURL(url);
    ods.setUser("hr");
    ods.setPassword("hr");
    ods.setConnectionCachingEnabled(true); // be sure set to true
    ods.setConnectionCacheProperties (prop);
    ods.setConnectionCacheName("ImplicitCache01"); // this cache's name


    // We need to create a connection to create the cache
    Connection conn = ds.getConnection(user, pass);
    Statement  stmt  = conn1.createStatement();
    ResultSet  rset  = stmt.executeQuery("select user from dual");
    conn1.close();

    ods.close();
```

Connection Attributes

Each connection obtained from a datasource can have attributes. Attributes are specified by the application developer, and are `java.lang.Properties` name/value pairs.

Developers use attributes to supply additional semantics to identify connection state. These semantics can include details like the language used by the connection, whether the connection is serializable, and so on. The connection cache enforces no restrictions on the value of connection attributes.

The methods that get and set connection attributes are found on `OracleConnection`.

Getting Connections

The first connection you retrieve has no attributes; you must set them. After you have set attributes on a connection, you can request those connections by attribute using the specialized forms of `getConnection`:

- `getConnection(java.util.Properties cachedConnectionAttributes)`—requests a database connection that matches the specified `cachedConnectionAttributes`
- `getConnection(java.lang.String user, java.lang.String passwd, java.util.Properties cachedConnectionAttributes)`—requests a database connection from the Implicit Connection Cache that matches the specified `user`, `passwd` and `cachedConnectionAttributes`. If null values are passed for `user` and `password`, the `DataSource` defaults are used.

The rules for what constitutes an attribute match are discussed in the next section.

Attribute Matching Rules

- The rules for matching `connectionAttributes` come in two variations:

  Basic, in which the cache is searched to retrieve the connection that matches the attributes.

  1. If an exact match is found, the connection is returned to the caller.
  2. If an exact match is not found and the `ClosestConnectionMatch` datasource property is set, then the connection with the closest match is returned. The closest matched connection is one that has the highest number of the original attributes matched. Note that the closest matched connection may match a subset of the original attributes, but does not have any attributes that are not part of the original list. For example, if the original list of attributes is A, B and C, then a closest match may have A and B set, but never a D.
  3. If none of the `connectionAttributes` are satisfied, a new connection is returned. The new connection is created using the user and password set on the `DataSource`.

- Advanced, where attributes may be associated with weights. The connection search mechanism is similar to the basic `connectionAttributes` based search, except that the connections are searched not only based on the `connectionAttributes`, but also using a set of weights that are associated with the keys on the `connectionAttributes`. These weights are assigned to the keys as a one time operation and is supported as a connection cache property, `AttributeWeights`. See "Attribute Weights And Connection Matching" on page 7-14 for further details.

Setting Connection Attributes

An application sets connection attributes using one of two methods:

- `applyConnectionAttributes(java.util.Properties connAttr)`

  No validation is done on `connAttr`. Applying connection attributes is cumulative: each time you invoke `applyConnectionAttributes`, the `connAttr` you supply are added to those previously in force.

- `close((java.util.Properties connAttr)`

  This obliterates the attributes of the specified connection and replaces them with the attributes found in `connAttr`.

Note: We recommend you do not invoke `applyConnectionAttributes(connAttr)` and `close(connAttr)` on the same connection.

Checking a Returned Connection's Attributes

When an application requests a connection with specified attributes, it is possible that no match will be found in the connection cache. When this happens, the connection cache creates a connection with no attributes and returns it. The connection cache cannot create a connection with the requested attributes, since the cache manager is ignorant of the semantics of the attributes.

Note: If the `closestConnectionMatch` property has been set, the cache manager looks for "close" attribute matches rather than exact matches; see "ClosestConnectionMatch" on page 7-9 for details.

For this reason, applications should always check the attributes of a returned connection. To do this, use the method `java.util.Properties getUnMatchedConnectionAttributes()`, which returns a list of any attributes that were not matched in retrieving the connection. If the return value of this method is `null`, you know that you must set all the connection attributes.

Connection Attribute Example

Example 7–3 illustrates using connection attributes.

Example 7–3 Using Connection Attributes

```
java.util.Properties connAttr = new java.util.Properties();
connAttr.setProperty("TRANSACTION_ISOLATION", "SERIALIZABLE");
connAttr.setProperty("CONNECTION_TAG", "JOE'S_CONNECTION");

// retrieve connection that matches attributes
Connection conn = ds.getConnection(connAttr);
// Check to see which attributes weren't matched
unmatchedProp = ((OracleConnection)conn).getUnMatchedConnectionAttributes();
if ( unmatchedProp != null )
{
// apply attributes to the connection
((OracleConnection)conn).applyConnectionAttributes(connAttr);
}
// verify whether conn contains property after apply attributes
connProp = ((OracleConnection)conn).getConnectionAttributes();
listProperties (connProp);
```

Connection Cache Properties

The connection cache properties govern the characteristics of a connection cache. This section lists the supported connection cache properties.

Applications set cache properties in one of the following ways:

- Using the `OracleDataSource` method `setConnectionCacheProperties()`
- When creating a cache using `OracleConnectionCacheManager`
- When re-initializing a cache using `OracleConnectionCacheManager`

Limit Properties

These properties control the size of the cache.

InitialLimit

Sets how many connections are created in the cache when it is created or reinitialized. When this property is set to an integer value greater than 0, creating or reinitializing the cache automatically creates the specified number of connections, filling the cache in advance of need.

Default: 0

MaxLimit

Sets the maximum number of connection instances the cache can hold. The default value is `Integer.MAX_VALUE`, meaning that there is no limit enforced by the connection cache, so that the number of connections is limited only by the number of database sessions configured for the database.

Default: `Integer.MAX_VALUE` (no limit)

MaxStatementsLimit

Sets the maximum number of statements that a connection keeps open. When a cache has this property set, reinitializing the cache or closing the datasource automatically closes all cursors beyond the specified `MaxStatementsLimit`.

Default: 0

MinLimit

Sets the minimum number of connections the cache maintains. This guarantees that the cache will not shrink below this minimum limit.

Setting the `MinLimit` property does not initialize the cache to contain the minimum number of connections. To do this, use the `InitialLimit` property. See "InitialLimit".

Default

0

Timeout Properties

These properties control the lifetime of an element in the cache.

InactivityTimeout

Sets the maximum time a physical connection can remain idle in a connection cache. An idle connection is one that is not active and does not have a logical handle

associated with it. When `InactivityTimeout` expires, the underlying physical connection is closed. However, the size of the cache is not allowed to shrink below minLimit, if has been set.

Default

0 (no timeout in effect)

TimeToLiveTimeout

Sets the maximum time in seconds that a logical connection can remain open. When TimeToLiveTimeout expires, the logical connection is unconditionally closed, the relevant statement handles are canceled, and the underlying physical connection is returned to the cache for reuse.

Default: 0 (no timeout in effect)

AbandonedConnectionTimeout

Sets the maximum time that a connection can remain unused before the connection is closed and returned to the cache. A connection is considered unused if it has not had SQL database activity.

When `AbandonedConnectionTimeout` is set, JDBC monitors SQL database activity on each logical connection. For example, when `stmt.execute()` is invoked on the connection, a heartbeat is registered to convey that this connection is active. The heartbeats are set at each database execution. If a connection has been inactive for the specified amount of time, the underlying connection is reclaimed and returned to the cache for reuse.

Default: 0 (no timeout in effect)

PropertyCheckInterval

Sets the time interval at which the cache manager inspects and enforces all specified cache properties. `PropertyCheckInterval` is set in seconds.

Default: 900 seconds (15 minutes)

Other Properties

These properties control miscellaneous cache behaviors.

AttributeWeights

See "AttributeWeights" on page 7-14.

ClosestConnectionMatch

See "ClosestConnectionMatch" on page 7-14.

ConnectionWaitTimeout

Specifies cache behavior when a connection is requested and there are already `MaxLimit` connections active. If `ConnectionWaitTimeout` is greater than zero (`0`), each connection request waits for the specified number of seconds, or until a connection is returned to the cache. If no connection is returned to the cache before the timeout elapses, the connection request returns null.

Default: 0 (no timeout)

LowerThresholdLimit

Sets the lower threshold limit on the cache. The default is 20% of the `MaxLimit` on the connection cache. This property is used whenever a `releaseConnection()` cache callback method is registered. For details, see "Connection Cache Callbacks" on page 7-15.

ValidateConnection

Setting `ValidateConnection` to `true` causes the connection cache to test every connection it retrieves against the underlying database.

Default: `false`

Connection Property Example

Example 7–4 demonstrates how an application uses connection properties.

Example 7–4 Using Connection Properties

```
import java.sql.*;
import javax.sql.*;
import java.util.*;
import javax.naming.*;
import javax.naming.spi.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.*;
...
  OracleDataSource ds =  (OracleDataSource) ctx.lookup("...");
  java.util.Properties prop = new java.util.Properties ();
  prop.setProperty("MinLimit", "5");     // the cache size is 5 at least
  prop.setProperty("MaxLimit", "25");
  prop.setProperty("InitialLimit", "3"); // create 3 connections at startup
  prop.setProperty("InactivityTimeout", "1800");    //  seconds
  prop.setProperty("AbandonedConnectionTimeout", "900");  //  seconds
  prop.setProperty("MaxStatementsLimit", "10");
  prop.setProperty("PropertyCheckInterval", "60"); // seconds

  ds.setConnectionCacheProperties (prop);  // set properties
  Connection conn = ds.getConnection();
  conn.dosomework();
  java.util.Properties propList=ds.getConnectionCacheProperties();  // retrieve
```

Connection Cache Manager API

`OracleConnectionCacheManager` provides administrative APIs that the middle tier can use to manage available connection caches. The administration methods are listed below; for full details, see the Javadoc.

- createCache
- removeCache
- reinitializeCache
- existsCache
- enableCache
- disableCache

- refreshCache
- purgeCache
- getCacheProperties
- getCacheNameList
- getNumberOfAvailableConnections
- getNumberOfActiveConnections
- setConnectionPoolDataSource

createCache

This method exists in two signature variants:

```
void createCache(String cacheName, javax.sql.DataSource ds,
   java.util.Properties cacheProps)
```

Creates a new cache identified by a unique cache name. The newly-created cache is bound to the specified `DataSource` object. Cache properties, when specified, are applied to the cache that gets created. When cache creation is successful, the Connection Cache Manager adds the new cache to the list of caches managed. Creating a cache with a user defined cache name facilitates specifying more meaningful names. For example, DMS metrics collected on a per cache basis could display metrics attached to a meaningful cache name. `createCache` throws an exception, if a cache already exists for the `DataSource` object passed in.

```
String createCache(javax.sql.DataSource ds, java.util.Properties cacheProps
```

Creates a new cache using a generated unique cache name and returns this cache name. The standard convention used in cache name generation is *`DataSourceName#HexRepresentationOfNumberOfCaches`*. The semantics are otherwise identical to the previous form.

removeCache

```
void removeCache(String cacheName, int timeout)
```

Removes the cache specified by `cacheName`. All its resources are closed and freed. The second parameter is a wait timeout value that is specified in seconds. If the wait timeout value is 0, then all in-use or checked out connections are reclaimed (similar to `TimeToLive` timeout) without waiting for the connections in-use to be done. When invoked with a wait timeout value greater than 0, the operation waits for the specified period of time for checked out connections to be closed before removing the connection cache. This includes connections that are closed based on timeouts specified. Connection cache removal is not reversible.

reinitializeCache

```
void reinitializeCache(String cacheName, java.util.properties
cacheProperties)
```

Reinitializes the cache using the specified new set of cache properties. This supports dynamic reconfiguration of caches; the new properties take effect on all newly-created connections, as well as on existing connections that are not in use. When the `reinitializeCache()` method is called, all in-use connections are closed. The new cache properties are then applied to all the connections in the cache.

Note: Invoking `reinitializeCache()` closes all connections obtained through this cache.

existsCache

```
boolean existsCache(String CacheName)
```

Checks whether a specific connection cache exists among the list of caches that the Connection Cache Manager handles. Returns `true` if the cache exists, `false` otherwise.

enableCache

```
void enableCache(String cacheName)
```

Enables a disabled cache. This is a no-op if the cache is already enabled.

disableCache

```
void disableCache(String cacheName)
```

Temporarily disables the cache specified by `cacheName`. This means that, temporarily, connection requests will not be serviced from this cache. However, in-use connections will continue to work uninterrupted.

refreshCache

```
void refreshCache(String cacheName, int mode)
```

Refreshes the cache specified by `cacheName`. There are two `modes` supported, `REFRESH_INVALID_CONNECTIONS` and `REFRESH_ALL_CONNECTIONS`. When invoked with `REFRESH_INVALID_CONNECTIONS`, each `Connection` in the cache is checked for validity. If an invalid `Connection` is found, that connection's resources are removed and replaced with a new `Connection`. The test for validity is basically a simple query to the dual table: `select 1 from dual`. When invoked with `REFRESH_ALL_CONNECTIONS`, all available connections in the cache are closed and replaced with new valid physical connections.

purgeCache

```
void  purgeCache(String cacheName, boolean cleanupCheckedOutConnections)
```

Removes connections from the connection cache, but does not remove the cache itself. If the `cleanupCheckedOutConnections` parameter is set to `true`, then the checked out connections are cleaned up, as well as the available connections in the cache. If the `cleanupCheckedOutConnections` parameter is set to false, only the available connections are cleaned up.

getCacheProperties

```
java.util.properties getCacheProperties(String cacheName)
```

Retrieves the cache properties for the specified `cacheName`.

getCacheNameList

```
String[] getCacheNameList()
```

Returns all the connection cache names that are known to the Connection Cache Manager. The cache names may then be used to manage connection caches using the Connection Cache Manager APIs.

getNumberOfAvailableConnections

```
int getNumberOfAvailableConnections(String cacheName)
```

Returns the number of connections in the connection cache, that are available for use. The value returned is a snapshot of the number of connections available in the connection cache at the time the API was processed; it may become invalid quickly.

getNumberOfActiveConnections

```
int getNumberOfActiveConnections(String cacheName)
```

Returns the number of checked out connections, connections that are active or busy, and hence not available for use. The value returned is a snapshot of the number of checked out connections in the connection cache at the time the API was processed; it may become invalid quickly.

setConnectionPoolDataSource

```
void setConnectionPoolDataSource(String cacheName, ConnectionPoolDataSource ds)
```

Allows connections to be created from an external `OracleConnectionPoolDataSource`, instead of the default `DataSource`, for the given connection cache. When such a `ConnectionPoolDataSource` is set, all `DataSource` properties, such as `url`, are derived from this new `DataSource`.

Example Of ConnectionCacheManager Use

Example 7–5 demonstrates the `OracleConnectionCacheManager` interfaces.

Example 7–5 Connection Cache Manager Example

```
import java.sql.*;
import javax.sql.*;
import java.util.*;
import javax.naming.*;
import javax.naming.spi.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.*;
...
// Get singleton ConnectionCacheManager instance
  OracleConnectionCacheManager occm =
  OracleConnectionCacheManager.getConnectionCacheManagerInstance();
  String cacheName = "foo";  // Look for a specific cache
  // Use Cache Manager to check # of available connections
  // and active connections
  System.out.println(occm.getNumberOfAvailableConnections(cacheName)
      " connections are available in cache " + cacheName);

  System.out.println(occm.getNumberOfActiveConnections(cacheName)
      + " connections are active");
```

```
// Refresh all connections in cache
occm.refreshCache(cacheName,
  OracleConnectionCacheManager.REFRESH_ALL_CONNECTIONS);
// Reinitialize cache, closing all connections
java.util.Properties newProp = new java.util.Properties();
newProp.setProperty("MaxLimit", "50");
occm.reinitializeCache(cacheName, newProp);
```

Advanced Topics

This section discusses cache functionality that is useful for advanced users, but is not essential to understanding or using the Implicit Connection Cache. This is divided into the following sections:

- Attribute Weights And Connection Matching
- Connection Cache Callbacks

Attribute Weights And Connection Matching

There are two connection cache properties that allow the developer to specify which connections in the connection cache are accepted in response to `agetConnection()` request. When you set the `ClosestConnectionMatch` property to `true`, you are telling the connection cache manager to return connections that match only some of the attributes you have specified.

If you do not specify `attributeWeights`, then the connection cache manager returns the connection that matches the highest number of attributes. If you specify `attributeWeights`, then you can control the priority the manager uses in matching attributes.

ClosestConnectionMatch

Setting `ClosestConnectionMatch` to `true` causes the connection cache to retrieve the connection with the closest approximation to the specified connection attributes. This can be used in combination with `AttributeWeights` to specify what is considered a "closest match".

Default: `false`

AttributeWeights

Sets the weights for each `connectionAttribute`. Used when `ClosestConnectionMatch` is set to `true` to determine which attributes are given highest priority when searching for matches. An attribute with a high weight is given more importance in determining a match than an attribute with a low weight.

`AttributeWeights` contains a set of Key/Value pairs that set the weights for each `connectionAttribute` for which the user intends to request a connection. The `Key` is a `connectionAttribute` and the `Value` is the weight; a weight must be an integer value greater than 0. The default weight is 1.

For example, `TRANSACTION_ISOLATION` could be assigned a weight of 10 and `ROLE` a weight of 5. If `ClosestConnectionMatch` is set to true, when a `connectionAttribute` based connection request is made on the cache, connections with a matching `TRANSACTION_ISOLATION` will be favored over connections with a matching `ROLE`.

Default: No `AttributeWeights`

Connection Cache Callbacks

The implicit connection cache offers a way for the application to specify callbacks to be invoked by the connection cache. Callback methods are supported with the `OracleConnectionCacheCallback` interface. This callback mechanism is useful to take advantage of the application's special knowledge of particular connections, supplementing the default behavior when handling abandoned connections or when the cache is empty.

`OracleConnectionCacheCallback` is an interface that must be implemented by the user and registered with `OracleConnection`. The registration API is:

```
public void
registerConnectionCacheCallback(
OracleConnectionCacheCallback cbk, Object usrObj,  int cbkflag);
```

In this interface, `cbk` is the user's implementation of the `OracleConnectionCacheCallback` interface. The `usrObj` parameter contains any parameters that the user wants supplied. This user object is passed back, unmodified, when the callback method is invoked. The `cbkflag` parameter specifies which callback method should be invoked. It must be one of the following values:

- `OracleConnection.ABANDONED_CONNECTION_CALLBACK`
- `OracleConnection.RELEASE_CONNECTION_CALLBACK`
- `OracleConnection.ALL_CALLBACKS`

When `ALL_CALLBACKS` is set, all the connection cache callback methods are invoked. For example,

```
// register callback, to invoke all callback methods
((OracleConnection)conn).registerConnectionCacheCallback( new
UserConnectionCacheCallback(),
  new SomeUserObject(),
OracleConnection.ALL_CALLBACKS);
```

An application can register a `ConnectionCacheCallback` on an `OracleConnection`. When a callback is registered, the connection cache calls the callback's `handleAbandonedConnection()` before reclaiming the connection. If the callback returns true, the connection is reclaimed. If the callback returns false, the connection remains active. For details, see "Connection Cache Manager API" on page 7-10.

The `UserConnectionCacheCallback` interface supports two callback methods to be implemented by the user, `releaseConnection()` and `handleAbandonedConnection()`. For details on these methods, see the Javadoc.

8

Fast Connection Failover

The Fast Connection Failover mechanism depends on the Implicit Connection Cache documented in Chapter 7, "Implicit Connection Caching". As a result, for Fast Connection Failover to be available, implicit connection caching must be enabled.

This chapter is divided into the following sections:

Introduction

Fast Connection Failover offers a driver-independent way for your JDBC application to take advantage of the connection failover facilities offered by 10*g* Release 1 (10.1). The advantages of Fast Connection Failover include:

- **Driver independence.** Fast Connection Failover supports both the Thin and OCI JDBC drivers.
- **Integration with the Implicit Connection Cache**. The two features work together synergistically to improve application performance and high availability.
- **Integration with RAC** for superior RAC/HA event notification mechanisms.
- **Easy integration with application code.** You simply enable Fast Connection Failover and forget it.

What Can Fast Connection Failover Do?

- **Rapid detection and cleanup of invalid cached connections (DOWN event processing)**.
- **Load balancing of available connections (UP event processing)**.
- **Runtime work request distribution to all active RAC instances**

Using Fast Connection Failover

Applications manage fast connection failover through `DataSource` instances.

Fast Connection Failover Prerequisites

Fast connection failover is available under the following circumstances:

- **The implicit connection cache is enabled.** Fast Connection Failover works in conjunction with the JDBC connection caching mechanism. This helps applications manage connections to ensure high availability.
- **The application uses service names to connect to the database;** the application cannot use service IDs.
- **The underlying database has Release 10 (10.1) Real Application Clusters (RAC) capability.** If failover events are not propagated, connection failover cannot occur.
- **Oracle Notification Service (ONS) is configured and available on the node where JDBC is running.** JDBC depends on ONS to propagate database events and notify JDBC of them.
- **The JVM in which your JDBC instance is running must have oracle.ons.oraclehome set to point to your ORACLE_HOME.**

Configuring ONS For Fast Connection Failover

In order for Fast Connection Failover to work, you must configure Oracle Notification Service (ONS) correctly. ONS is shipped as part of 10*g* Release 1 (10.1).

ONS Configuration File

ONS configuration is controlled by the ONS configuration file, *`ORACLE_HOME`*`/opmn/conf/ons.config`. This file tells the ONS daemon details about how it should behave and who it should talk to. Configuration information within `ons.config` is defined in simple name/value pairs. There are three values that should always be configured within `ons.config`. The first is `localport`, the port that ONS binds to on the localhost interface to talk to local clients. An example of the localport configuration is:

```
localport=4100
```

The second value is `remoteport`, the port that ONS binds to on all interfaces for talking to other ONS daemons. An example of the `remoteport` configuration is:

```
remoteport=4200
```

The third value specifies `nodes`, a list of other ONS daemons to talk to. Node values are given as a comma-separated list of either hostnames or IP addresses plus ports. Note that the port value that is given is the remote port that each ONS instance is listening on. In order to maintain an identical file on all nodes, the host:port of the current ONS node can also be listed in the nodes list. It will be ignored when reading the list.

The nodes listed in the nodes line correspond to the individual nodes in the RAC cluster. Listing the nodes ensures that the mid-tier node can communicate with the RAC nodes. At least one mid-tier node and one node in the RAC cluster must be configured to see one another. As long as one node on each side is aware of the other, all nodes are visible. You need not list every single cluster and mid-tier node in each

RAC node's ONS config file. In particular, if one RAC cluster node is aware of the mid-tier, all nodes in the cluster are aware of it.

An example of the nodes configuration is:

```
nodes=myhost.example.com:4200,123.123.123.123:4200
```

There are also several optional values that can be provided in `ons.config`.

The first optional value is a `loglevel`. This specifies the level of messages that should be logged by ONS. This value is an integer that ranges from 1 (least messages logged) to 9 (most messages logged, use only for debugging purposes). The default value is 3. An example is:

```
loglevel=3
```

The second optional value is a `logfile` name. This specifies a log file that ONS should use for logging messages. The default value for `logfile` is *`$ORACLE_HOME`*`/opmn/logs/ons.log`. An example is:

```
logfile=/private/oraclehome/opmn/logs/myons.log
```

The third optional value is a `walletfile` name. A wallet file is used by the Oracle SSL layer to store SSL certificates. If a wallet file is specified to ONS, it will use SSL when communicating with other ONS instances and require SSL certificate authentication from all ONS instances that try to connect to it. This means that if you want to turn on SSL for one ONS instance, you must turn it on for all instances that are connected. This value should point to the directory where your `ewallet.p12` file is located. An example is:

```
walletfile=/private/oraclehome/opmn/conf/ssl.wlt/default
```

One optional value is reserved for use on the server side. `useocr=on` is used to tell ONS to store all RAC nodes and port numbers in Oracle Cluster Registry (OCR) instead of in the ONS configuration file. Do not use this option on the client side.

The `ons.config` file allows blank lines and comments on lines that begin with `#`.

Client-side ONS Configuration

On the client side, you must configure the RAC nodes in the ONS configuration file. A sample configuration file might look like this:

Example 8–1 ons.config file

```
# This is an example ons.config file
#
# The first three values are required
localport=4100
remoteport=4200
nodes=racnode1.example.com:4200,racnode2.example.com:4200
```

After configuring ONS, you start the ONS daemon with the `onsctl` command. It is the user's responsibility to make sure that an ONS daemon is running at all times.

Using the oncstl Command After configuring, you use *`ORACLE_HOME`*`/opmn/bin/onsctl` to start, stop, reconfigure, and monitor the ONS daemon. Table 8–1 is a summary of the commands that `onsctl` supports.

Table 8–1 onsctl commands

Command	Effect	Output
`start`	starts the ONS daemon	onsctl: ons started
`stop`	stops the ONS daemon	onsctl: shutting down ons daemon...
`ping`	Verifies whether the ONS daemon is running	ons is running ...
`reconfig`	triggers a reload of the ONS configuration without shutting down the ONS daemon	
`help`	prints a help summary message for onsctl	
`detailed`	prints a detailed help message for onsctl	

Server-side ONS Configuration Using racgons

You configure the server side by using `racgons` to add the mid-tier node information to OCR. This command is found in `ORA_CRS_HOME/bin/racgons`. Before using `racgons`, you must edit `ons.config` to set `useocr=on`.

The mid-tier node(s) should be configured in OCR so that all nodes share the configuration, and no matter which RAC nodes are up they can communicate to the mid-tier. When running on a cluster, always configure the ONS hosts and ports not by using the ONS configuration files but using `racgons`. The `racgons` command stores the ONS hosts and ports in OCR, where every node can see it. That way, you don't need to edit a file on every node to change the configuration, just run a single command on one of the cluster nodes.

The `racogns` command allows you to specify hosts and ports on one node, then propagate your changes among all nodes in a cluster. The command takes two forms:

```
racgons add_config hostname:port [hostname:port] [hostname:port] ...
racgons remove_config hostname[:port] [hostname:port] [hostname:port] ...
```

The `add_config` version adds the listed hostname(s), the `remove_config` version removes them. Both commands propagate the changes among all instances in a cluster.

If multiple port numbers are configured for a host, the specified port number is removed from *`hostname`*. If only *`hostname`* is specified, all port numbers for that host are removed.

Other Uses of racgons You should run `racgons` whenever you add a new node to the cluster.

Enabling Fast Connection Failover

An application enables fast connection failover by invoking `setFastConnectionFailoverEnabled(true);` on a `DataSource` instance before retrieving any connections from that instance.

You cannot enable Fast Connection Failover when reinitializing a connection cache; you must enable it before using the `OracleDataSource`.

Note: After a cache is Fast Connection Failover-enabled, you cannot disable Fast Connection Failover during the lifetime of that cache.

To enable fast connection failover, you must:

- Configure and start ONS. If ONS is not correctly set up, implicit connection cache creation fails and an `ONSException` is thrown at the first `getConnection()` request. See "Configuring ONS For Fast Connection Failover".
- Set the `FastConnectionFailoverEnabled` property before making the first `getConnection()` request to an `OracleDataSource`. When Fast Connection Failover is enabled, the failover applies to all connections in the connection cache. If your application explicitly creates a connection cache using the Connection Cache Manager, you must first set `FastConnectionFailoverEnabled` before retrieving any connections.
- Use a service name rather than a SID when setting the `OracleDataSource url` property.

Example 8–2 Enabling Fast Connection Failover

```
// declare datasource
ods.setUrl(
"jdbc:oracle:oci:@(DESCRIPTION=
  (ADDRESS=(PROTOCOL=TCP)(HOST=cluster_alias)
    (PORT=1521))
    (CONNECT_DATA=(SERVICE_NAME=service_name)))");
ods.setUser("scott");
ods.setConnectionCachingEnabled(true);
ods.setFastConnectionFailoverEnabled(true):
ctx.bind("myDS",ods);
ds=(OracleDataSource) ctx.lookup("MyDS");
try {
 dx.getConnection();  // transparently creates and accesses cache
 catch (SQLException SE {
  }
 catch (ONSException ONS {
  // Work can continue here, but cache is not FCF enabled
 }

}
...
```

Querying Fast Connection Failover Status

An application determines whether fast connection failover is enabled by calling `OracleDataSource.getFastConnectionFailoverEnabled()`, which returns `true` if failover is enabled, `false` otherwise.

Understanding Fast Connection Failover

After Fast Connection Failover is enabled, the mechanism is automatic; no application intervention is needed. This section discusses how a connection failover is presented to an application and what steps the application takes to recover.

What The Application Sees

When a RAC service failure is propagated to the JDBC application, the database has already rolled back the local transaction. The cache manager then cleans up all invalid connections. When an application holding an invalid connection tries to do work through that connection, it receives a `SQLException` ORA-17008, Closed Connection.

When an application receives a `Closed Connection` error message, it should:

1. **Retry the connection request.** This is essential, because the old connection is no longer open.
2. **Replay the transaction.** All work done before the connection was closed has been lost.

> **Note:** The application should not try to roll back the transaction; the transaction was already rolled back in the database by the time the application received the exception.

What's Happening

Under Fast Connection Failover, each connection in the cache maintains a mapping to a service, instance, database, and hostname.

When a database generates a RAC event, that event is forwarded to the virtual machine in which JDBC is running. A daemon thread inside the virtual machine receives the RAC event and passes it on to the connection cache manager. The connection cache manager then throws SQL exceptions to the applications affected by the RAC event.

A typical failover scenario might work like this:

1. A database instance fails, leaving several stale connections in the cache.
2. The RAC mechanism in the database generates a RAC event which is sent to the virtual machine containing JDBC.
3. The daemon thread inside the virtual machine finds all the connections affected by the RAC event, notifies them of the closed connection via SQL exceptions, and rolls back any open transactions.
4. Each individual connection receives a SQL exception and must retry.

Comparison of Fast Connection Failover and TAF

Fast Connection Failover differs from TAF in the following ways:

- **Application-Level Connection Retries**. Fast Connection Failover supports application-level connection retries. This gives the application control of responding to connection failovers: the application can choose whether to retry the connection or to rethrow the exception. TAF supports connection retries only at the OCI/Net layer.
- **Integration with the Connection Cache**. Fast Connection Failover is well-integrated with the Implicit Connection Cache, which allows the connection cache manager to manage the cache for high availability. For example, failed connections are automatically invalidated in the cache. TAF works at the network level on a per-connection basis, which means that the connection cache cannot be notified of failures.
- **Event-Based.** Fast Connection Failover is based on the RAC event mechanism. This means that Fast Connection Failover is efficient and detects failures quickly for both active and inactive connections. TAF is based on the network call mechanism.

- **Load-Balancing Support.** Fast Connection Failover supports UP event load balancing of connections and runtime work request distribution across active RAC instances.

> **Note:** We do not recommend using Transparent Application Failover (TAF) and Fast Application Failover in the same application.

9

Distributed Transactions

This chapter discusses the Oracle JDBC implementation of distributed transactions. These are multi-phased transactions, often using multiple databases, that must be committed in a coordinated way. There is also related discussion of XA, which is a general standard (not specific to Java) for distributed transactions.

The following topics are discussed:

> **Note:** This chapter discusses features of the JDBC 2.0 Optional Package, formerly known as the JDBC 2.0 Standard Extension API, which is available through the `javax` packages from Sun Microsystems. The Optional Package is part of JDK 1.4. For JDK 1.2.x and 1.3.x, the relevant packages are included in the `classes12.jar` file.

For further introductory and general information about distributed transactions, refer to the Sun Microsystems specifications for the JDBC 2.0 Optional Package and the Java Transaction API (JTA).

For information on the OCI-specific HeteroRM XA feature, see "OCI HeteroRM XA" on page 19-9.

Overview

A *distributed transaction*, sometimes referred to as a *global transaction*, is a set of two or more related transactions that must be managed in a coordinated way. The transactions that constitute a distributed transaction might be in the same database, but more typically are in different databases and often in different locations. Each individual transaction of a distributed transaction is referred to as a *transaction branch*.

For example, a distributed transaction might consist of money being transferred from an account in one bank to an account in another bank. You would not want either transaction committed without assurance that both will complete successfully.

In the JDBC 2.0 extension API, distributed transaction functionality is built on top of connection pooling functionality. This distributed transaction functionality is also built

upon the open XA standard for distributed transactions. (XA is part of the X/Open standard and is not specific to Java.)

JDBC is used to connect to database resources. However, to include all changes to multiple databases within a transaction, you must use the JDBC connections within a JTA global transaction. The process of including database SQL updates within a transaction is referred to as enlisting a database resource.

The remainder of this overview covers the following topics:

- Distributed Transaction Components and Scenarios
- Distributed Transaction Concepts
- Switching Between Global and Local Transactions
- Oracle XA Packages

For further introductory and general information about distributed transactions and XA, refer to the Sun Microsystems specifications for the JDBC 2.0 Optional Package and the Java Transaction API.

Distributed Transaction Components and Scenarios

In reading the remainder of the distributed transactions section, it will be helpful to keep the following points in mind:

- A distributed transaction system typically relies on an external *transaction manager*—such as a software component that implements standard Java Transaction API functionality—to coordinate the individual transactions.

  Many vendors offer XA-compliant JTA modules, including Oracle, which includes JTA in Oracle 9*i*AS and Oracle Application Server 10*g*.

- XA functionality is usually isolated from a client application, being implemented instead in a middle-tier environment such as an application server.

  In many scenarios, the application server and transaction manager will be together on the middle tier, possibly together with some of the application code as well.

- Discussion throughout this section is intended mostly for middle-tier developers.

- The term *resource manager* is often used in discussing distributed transactions. A resource manager is simply an entity that manages data or some other kind of resource. Wherever the term is used in this chapter, it refers to a database.

Note: Using JTA functionality requires file `jta.jar` to be in the `CLASSPATH`. (This file is located at *`ORACLE_HOME`*`/jlib`.) Oracle includes this file with the JDBC product. (You can also obtain it from the Sun Microsystems Web site, but it is advisable to use the version from Oracle, because that has been tested with the Oracle drivers.)

Distributed Transaction Concepts

When you use XA functionality, the transaction manager uses *XA resource* instances to prepare and coordinate each transaction branch and then to commit or roll back all transaction branches appropriately.

XA functionality includes the following key components:

- XA datasources—These are extensions of connection pool datasources and other datasources, and similar in concept and functionality.

  There will be one XA datasource instance for each resource manager (database) that will be used in the distributed transaction. You will typically create XA datasource instances (using the class constructor) in your middle-tier software.

  XA datasources produce XA connections.

- XA connections—These are extensions of pooled connections, and similar in concept and functionality. An XA connection encapsulates a physical database connection; individual connection instances are temporary handles to these physical connections.

  An XA connection instance corresponds to a single Oracle session, although the session can be used in sequence by multiple logical connection instances (one at a time), as with pooled connection instances.

  You will typically get an XA connection instance from an XA datasource instance (using a `getXAConnection` method) in your middle-tier software. You can get multiple XA connection instances from a single XA datasource instance if the distributed transaction will involve multiple sessions (multiple physical connections) in the same database.

  XA connections produce XA resource instances and JDBC connection instances.

- XA resources—These are used by a transaction manager in coordinating the transaction branches of a distributed transaction.

  You will get one XA resource instance from each XA connection instance (using a `getXAResource` method), typically in your middle-tier software. There is a one-to-one correlation between XA resource instances and XA connection instances; equivalently, there is a one-to-one correlation between XA resource instances and Oracle sessions (physical connections).

  In a typical scenario, the middle-tier component will hand off XA resource instances to the transaction manager, for use in coordinating distributed transactions.

  Because each XA resource instance corresponds to a single Oracle session, there can be only a single active transaction branch associated with an XA resource instance at any given time. There can be additional suspended transaction branches, however—see "XA Resource Method Functionality and Input Parameters" on page 9-8.

  Each XA resource instance has the functionality to start, end, prepare, commit, or roll back the operations of the transaction branch running in the session with which the XA resource instance is associated.

  The "prepare" step is the first step of a two-phase `COMMIT` operation. The transaction manager will issue a `prepare` to each XA resource instance. Once the transaction manager sees that the operations of each transaction branch have prepared successfully (essentially, that the databases can be accessed without error), it will issue a `COMMIT` to each XA resource instance to commit all the changes.

- Transaction IDs—These are used to identify transaction branches. Each ID includes a transaction branch ID component and a distributed transaction ID component—this is how a branch is associated with a distributed transaction. All XA resource instances associated with a given distributed transaction would have a transaction ID that includes the same distributed transaction ID component.

Switching Between Global and Local Transactions

As of JDBC 3.0, applications can share connections between local and global transactions. Applications can also switch connections between local transactions and global transactions.

A connection is always in one of three modes: `NO_TXN`, `LOCAL_TXN`, or `GLOBAL_TXN`.

- **`NO_TXN`** —no transaction is actively using this connection.
- **`LOCAL_TXN`**—a local transaction with auto-commit turned off or disabled is actively using this connection.
- **`GLOBAL_TXN`**—a global transaction is actively using this connection.

Each connection switches automatically between these modes depending on the operations executed on the connection. A connection is always in `NO_TXN` mode when it is instantiated.

Table 9–1 Connection Mode Transitions

Current Mode	Switches To NO_TXN When	Switches to LOCAL_TXN When	Switches To GLOBAL_TXN When
NO_TXN	n/a	Auto-commit mode is false and an Oracle DML (`SELECT`, `INSERT`, `UPDATE`) statement is executed	`start()` is invoked on an `XAResource` obtained from the `XAconnection` that provided this connection
LOCAL_TXN	Any of the following happens: An Oracle DDL statement (`CREATE`, `DROP`, `RENAME`, `ALTER`) is executed. `commit()` is invoked. `rollback()` is invoked (parameterless version only).	n/a	**NEVER**
GLOBAL_TXN	Within a global transaction open on this connection, `end()` is invoked on an `XAResource` obtained from the `XAconnection` that provided this connection.	**NEVER**	n/a

If none of the rules above is applicable, the mode does not change.

Mode Restrictions On Operations

The current connection mode restricts which operations are valid within a transaction.

- In `LOCAL_TXN` mode, applications must not invoke `prepare()`, `commit()`, `rollback()`, `forget()`, or `end()` on an `XAResource`. Doing so causes an `XAException` to be thrown.

- In `GLOBAL_TXN` mode, applications must not invoke `commit()`, `rollback()` (both versions), `setAutoCommit()`, or `setSavepoint() on a java.sql.Connection`, and must not invoke `OracleSetSavepoint()` or `oracleRollback()` on an `oracle.jdbc.OracleConnection`. Doing so causes an `SQLException` to be thrown.

> **Note:** This mode-restriction error checking is in addition to the standard error checking on the transaction and savepoint APIs, documented in this chapter and in "Transaction Savepoints" on page 5-4.

Oracle XA Packages

Oracle supplies the following three packages that have classes to implement distributed transaction functionality according to the XA standard:

- `oracle.jdbc.xa` (`OracleXid` and `OracleXAException` classes)
- `oracle.jdbc.xa.client`
- `oracle.jdbc.xa.server`

Classes for XA datasources, XA connections, and XA resources are in both the `client` package and the `server` package. (An abstract class for each is in the top-level package.) The `OracleXid` and `OracleXAException` classes are in the top-level `oracle.jdbc.xa` package, because their functionality does not depend on where the code is running.

In middle-tier scenarios, you will import `OracleXid`, `OracleXAException`, and the `oracle.jdbc.xa.client` package.

If you intend your XA code to run in the target Oracle database, however, you will import the `oracle.jdbc.xa.server` package instead of the `client` package.

If code that will run inside a target database must also access remote databases, then do not import either package—instead, you must fully qualify the names of any classes that you use from the `client` package (to access a remote database) or from the `server` package (to access the local database). Class names are duplicated between these packages.

XA Components

This section discusses the XA components—standard XA interfaces specified in the JDBC 2.0 Optional Package, and the Oracle classes that implement them. The following topics are covered:

XA Datasource Interface and Oracle Implementation

The `javax.sql.XADataSource` interface outlines standard functionality of XA datasources, which are factories for XA connections. The overloaded

getXAConnection() method returns an XA connection instance and optionally takes a user name and password as input:

```
public interface XADataSource
{
   XAConnection getXAConnection() throws SQLException;
   XAConnection getXAConnection(String user, String password)
      throws SQLException;
   ...
}
```

Oracle JDBC implements the XADataSource interface with the OracleXADataSource class, located both in the oracle.jdbc.xa.client package and the oracle.jdbc.xa.server package.

The OracleXADataSource classes also extend the OracleConnectionPoolDataSource class (which extends the OracleDataSource class), so include all the connection properties described in "DataSource Properties" on page 3-2.

The OracleXADataSource class getXAConnection() methods return the Oracle implementation of XA connection instances, which are OracleXAConnection instances (as the next section discusses).

> **Note:** You can register XA datasources in JNDI using the same naming conventions as discussed previously for non-pooling datasources in "Register the Datasource" on page 3-7.

XA Connection Interface and Oracle Implementation

An XA connection instance, as with a pooled connection instance, encapsulates a physical connection to a database. This would be the database specified in the connection properties of the XA datasource instance that produced the XA connection instance.

Each XA connection instance also has the facility to produce the XA resource instance that will correspond to it for use in coordinating the distributed transaction.

An XA connection instance is an instance of a class that implements the standard javax.sql.XAConnection interface:

```
public interface XAConnection extends PooledConnection
{
   javax.jta.xa.XAResource getXAResource() throws SQLException;
}
```

As you see, the XAConnection interface extends the javax.sql.PooledConnection interface, so it also includes the getConnection(), close(), addConnectionEventListener(), and removeConnectionEventListener() methods.

Oracle JDBC implements the XAConnection interface with the OracleXAConnection class, located both in the oracle.jdbc.xa.client package and the oracle.jdbc.xa.server package.

The OracleXAConnection classes also extend the OraclePooledConnection class.

The OracleXAConnection class getXAResource() method returns the Oracle implementation of an XA resource instance, which is an OracleXAResource instance

(as the next section discusses). The `getConnection()` method returns an `OracleConnection` instance.

A JDBC connection instance returned by an XA connection instance acts as a temporary handle to the physical connection, as opposed to encapsulating the physical connection. The physical connection is encapsulated by the XA connection instance.

Each time an XA connection instance `getConnection()` method is called, it returns a new connection instance that exhibits the default behavior, and closes any previous connection instance that still exists and had been returned by the same XA connection instance. It is advisable to explicitly close any previous connection instance before opening a new one, however.

Calling the `close()` method of an XA connection instance closes the physical connection to the database. This is typically performed in the middle tier.

XA Resource Interface and Oracle Implementation

The transaction manager uses XA resource instances to coordinate all the transaction branches that constitute a distributed transaction.

Each XA resource instance provides the following key functionality, typically invoked by the transaction manager:

- It associates and disassociates distributed transactions with the transaction branch operating in the XA connection instance that produced this XA resource instance. (Essentially, associates distributed transactions with the physical connection or session encapsulated by the XA connection instance.) This is done through use of transaction IDs.
- It performs the two-phase `COMMIT` functionality of a distributed transaction to ensure that changes are not committed in one transaction branch before there is assurance that the changes will succeed in all transaction branches.

  "XA Resource Method Functionality and Input Parameters" on page 9-8 further discusses this.

  Notes:

  - Because there must always be a one-to-one correlation between XA connection instances and XA resource instances, an XA resource instance is implicitly closed when the associated XA connection instance is closed.
  - If a transaction is opened by a given XA resource instance, it must also be closed by the same XA resource instance.

An XA resource instance is an instance of a class that implements the standard `javax.transaction.xa.XAResource` interface:

```
public interface XAResource
{
   void commit(Xid xid, boolean onePhase) throws XAException;
   void end(Xid xid, int flags) throws XAException;
   void forget(Xid xid) throws XAException;
   int prepare(Xid xid) throws XAException;
   Xid[] recover(int flag) throws XAException;
   void rollback(Xid xid) throws XAException;
   void start(Xid xid, int flags) throws XAException;
   boolean isSameRM(XAResource xares) throws XAException;
```

```
}
```

Oracle JDBC implements the `XAResource` interface with the `OracleXAResource` class, located both in the `oracle.jdbc.xa.client package` and the `oracle.jdbc.xa.server` package.

The Oracle JDBC driver creates and returns an `OracleXAResource` instance whenever the `OracleXAConnection` class `getXAResource()` method is called, and it is the Oracle JDBC driver that associates an XA resource instance with a connection instance and the transaction branch being executed through that connection.

This method is how an `OracleXAResource` instance is associated with a particular connection and with the transaction branch being executed in that connection.

XA Resource Method Functionality and Input Parameters

The `OracleXAResource` class has several methods to coordinate a transaction branch with the distributed transaction with which it is associated. This functionality usually involves two-phase `COMMIT` operations.

A transaction manager, receiving `OracleXAResource` instances from a middle-tier component such as an application server, typically invokes this functionality.

Each of these methods takes a transaction ID as input, in the form of an `Xid` instance, which includes a transaction branch ID component and a distributed transaction ID component. Every transaction branch has a unique transaction ID, but transaction branches belonging to the same global transaction have the same global transaction component as part of their transaction IDs.

"XA ID Interface and Oracle Implementation" on page 9-12 discusses the `OracleXid` class and the standard interface upon which it is based.

Following is a description of key XA resource functionality, the methods used, and additional input parameters. Each of these methods throws an XA exception if an error is encountered. See "XA Exception Classes and Methods" on page 9-13.

Start

Start work on behalf of a transaction branch, associating the transaction branch with a distributed transaction.

```
void start(Xid xid, int flags)
```

The `flags` parameter must be one of the following values:

- `XAResource.TMNOFLAGS` (no special flag)—Flag the start of a new transaction branch for subsequent operations in the session associated with this XA resource instance. This branch will have the transaction ID `xid`, which is an `OracleXid` instance created by the transaction manager. This will map the transaction branch to the appropriate distributed transaction.
- `XAResource.TMJOIN`—Join subsequent operations in the session associated with this XA resource instance to the existing transaction branch specified by `xid`.
- `XAResource.TMRESUME`—Resume the transaction branch specified by `xid`. (It must first have been suspended.)
- `OracleXAResource.ORATMSERIALIZABLE`—Start a serializable transaction with transaction ID `xid`.
- `OracleXAResource.ORATMREADONLY`—Start a read-only transaction with transaction ID `xid`.

- `OracleXAResource.ORATMREADWRITE`—Start a read/write transaction with transaction ID `xid`.
- `OracleXAResource.ORATRANSLOOSE`—start a loosely-coupled transaction with transaction ID `xid`.

`TMNOFLAGS`, `TMJOIN`, `TMRESUME`, `ORATMSERIALIZABLE`, `ORATMREADONLY`, and `ORATMREADWRITE` are defined as static members of the `XAResource` interface and `OracleXAResource` class. `ORATMSERIALIZABLE`, `ORATMREADONLY`, and `ORATMREADWRITE` are the isolation-mode flags. The default isolation behavior is `READ COMMITTED`.

Notes:

- Instead of using the `start()` method with `TMRESUME`, the transaction manager can cast to an `OracleXAResource` instance and use the `resume(Xid xid)` method, an Oracle extension.
- If you use `TMRESUME`, you must also use `TMNOMIGRATE`, as in `start(xid, XAResource.TMRESUME | OracleXAResource.TMNOMIGRATE);`. This prevents the application's receiving the error `ORA 1002: fetch out of sequence.`
- If you use the isolation-mode flags incorrectly, an exception with code `XAER_INVAL` is raised. Furthermore, you cannot use isolation-mode flags when resuming a global transaction, because you cannot set the isolation level of an existing transaction. If you try to use the isolation-mode flags when resuming a transaction, an external Oracle exception with code ORA-24790 is raised.
- In order to avoid `Error ORA 1002: fetch out of sequence`, include the `TMNOMIGRATE` flag as part of the `start` method. For example:

```
start(xid, XAResource.TMSUSPEND |
OracleXAResource.TMNOMIGRATE);
```

- All the flags defined in `OracleXAResource` are Oracle extensions. When writing a transaction manager that uses these flags, you should be mindful of this.

Note that to create an appropriate transaction ID in starting a transaction branch, the transaction manager must know which distributed transaction the transaction branch should belong to. The mechanics of this are handled between the middle tier and transaction manager and are beyond the scope of this document. Refer to the Sun Microsystems specifications for the JDBC 2.0 Optional Package and the Java Transaction API.

End

End work on behalf of the transaction branch specified by `xid`, disassociating the transaction branch from its distributed transaction.

```
void end(Xid xid, int flags)
```

The `flags` parameter can have one of the following values:

- `XAResource.TMSUCCESS`—This is to indicate that this transaction branch is known to have succeeded.

- XAResource.TMFAIL—This is to indicate that this transaction branch is known to have failed.
- XAResource.TMSUSPEND—This is to suspend the transaction branch specified by xid. (By suspending transaction branches, you can have multiple transaction branches in a single session. Only one can be active at any given time, however. Also, this tends to be more expensive in terms of resources than having two sessions.)

TMSUCCESS, TMFAIL, and TMSUSPEND are defined as static members of the XAResource interface and OracleXAResource class.

Notes:

- Instead of using the end() method with TMSUSPEND, the transaction manager can cast to an OracleXAResource instance and use the suspend(Xid xid) method, an Oracle extension.
- This XA functionality to suspend a transaction provides a way to switch between various transactions within a single JDBC connection. You can use the XA classes to accomplish this, even if you are not in a distributed transaction environment and would otherwise have no need for the XA classes.
- If you use TMSUSPEND, you must also use TMNOMIGRATE, as in end(xid, XAResource.TMSUSPEND | OracleXAResource.TMNOMIGRATE);. This prevents the application's receiving the error ORA 1002: fetch out of sequence.
- In order to avoid Error ORA 1002: fetch out of sequence, include the TMNOMIGRATE flag as part of the end method. For example:

```
end(xid, XAResource.TMSUSPEND |
OracleXAResource.TMNOMIGRATE);
```

Prepare

Prepare the changes performed in the transaction branch specified by xid. This is the first phase of a two-phase COMMIT operation, to ensure that the database is accessible and that the changes can be committed successfully.

```
int prepare(Xid xid)
```

This method returns an integer value as follows:

- XAResource.XA_RDONLY—This is returned if the transaction branch executes only read-only operations such as SELECT statements.
- XAResource.XA_OK—This is returned if the transaction branch executes updates that are all prepared without error.
- n/a (no value returned)—No value is returned if the transaction branch executes updates and any of them encounter errors during preparation. In this case, an XA exception is thrown.

XA_RDONLY and XA_OK are defined as static members of the XAResource interface and OracleXAResource class.

Notes:

- Always call the `end()` method on a branch before calling the `prepare()` method.
- If there is only one transaction branch in a distributed transaction, then there is no need to call the `prepare()` method. You can call the XA resource `commit()` method without preparing first.

Commit

Commit prepared changes in the transaction branch specified by `xid`. This is the second phase of a two-phase `COMMIT` and is performed only after all transaction branches have been successfully prepared.

```
void commit(Xid xid, boolean onePhase)
```

Set the `onePhase` parameter as follows:

- `true`—This is to use one-phase instead of two-phase protocol in committing the transaction branch. This is appropriate if there is only one transaction branch in the distributed transaction; the `prepare` step would be skipped.
- `false`—This is to use two-phase protocol in committing the transaction branch (typical).

Roll back

Rolls back prepared changes in the transaction branch specified by `xid`.

```
void rollback(Xid xid)
```

Forget

Tells the resource manager to forget about a heuristically completed transaction branch.

```
public void forget(Xid xid)
```

Recover

The transaction manager calls this method during recovery to obtain the list of transaction branches that are currently in prepared or heuristically completed states.

```
public Xid[] recover(int flag)
```

Note: Values for `flag` other than `TMSTARTRSCAN`, `TMENDRSCAN`, or `TMNOFLAGS`, cause an exception to be thrown; otherwise `flag` is ignored.

The resource manager returns zero or more `Xid`s for the transaction branches that are currently in a prepared or heuristically completed state. If an error occurs during the operation, the resource manager throws the appropriate `XAException`.

Check for same RM

To determine if two XA resource instances correspond to the same resource manager (database), call the `isSameRM()` method from one XA resource instance, specifying

the other XA resource instance as input. In the following example, presume `xares1` and `xares2` are `OracleXAResource` instances:

```
boolean sameRM = xares1.isSameRM(xares2);
```

A transaction manager can use this method regarding certain Oracle optimizations, as "Oracle XA Optimizations" on page 9-14 explains.

XA ID Interface and Oracle Implementation

The transaction manager creates transaction ID instances and uses them in coordinating the branches of a distributed transaction. Each transaction branch is assigned a unique transaction ID, which includes the following information:

- format identifier (4 bytes)

  A format identifier specifies a Java transaction manager—for example, there could be a format identifier `ORCL`. This field *cannot* be null.

- global transaction identifier (64 bytes) (or "distributed transaction ID component", as discussed earlier)
- branch qualifier (64 bytes) (or "transaction branch ID component", as discussed earlier)

The 64-byte global transaction identifier value will be identical in the transaction IDs of all transaction branches belonging to the same distributed transaction. The overall transaction ID, however, is unique for every transaction branch.

An XA transaction ID instance is an instance of a class that implements the standard `javax.transaction.xa.Xid` interface, which is a Java mapping of the X/Open transaction identifier XID structure.

Oracle implements this interface with the `OracleXid` class in the `oracle.jdbc.xa` package. `OracleXid` instances are employed only in a transaction manager, transparent to application programs or an application server.

> **Note:** Oracle does not require the use of `OracleXid` for Oracle XA resource calls. Instead, use any class that implements the `javax.transaction.xa.Xid` interface.

A transaction manager may use the following in creating an `OracleXid` instance:

```
public OracleXid(int fId, byte gId[], byte bId[]) throws XAException
```

Where `fId` is an integer value for the format identifier, `gId[]` is a byte array for the global transaction identifier, and `bId[]` is a byte array for the branch qualifier.

The `Xid` interface specifies the following getter methods:

- `public int getFormatId()`
- `public byte[] getGlobalTransactionId()`
- `public type[] getBranchQualifier()`

Error Handling and Optimizations

This section has two focuses: 1) the functionality of XA exceptions and error handling; and 2) Oracle optimizations in its XA implementation. The following topics are covered:

- XA Exception Classes and Methods
- Mapping between Oracle Errors and XA Errors
- XA Error Handling
- Oracle XA Optimizations

The exception and error-handling discussion includes the standard XA exception class and the Oracle-specific XA exception class, as well as particular XA error codes and error-handling techniques.

XA Exception Classes and Methods

XA methods throw XA exceptions, as opposed to general exceptions or `SQLExceptions`. An XA exception is an instance of the standard class `javax.transaction.xa.XAException` or a subclass. Oracle subclasses `XAException` with the `oracle.jdbc.xa.OracleXAException` class.

An `OracleXAException` instance consists of an Oracle error portion and an XA error portion and is constructed as follows by the Oracle JDBC driver:

```
public OracleXAException()
```

or:

```
public OracleXAException(int error)
```

The error value is an error code that combines an Oracle SQL error value and an XA error value. (The JDBC driver determines exactly how to combine the Oracle and XA error values.)

The `OracleXAException` class has the following methods:

- `public int getOracleError()`

  This method returns the Oracle SQL error code pertaining to the exception—a standard ORA error number (or 0 if there is no Oracle SQL error).

- `public int getXAError()`

  This method returns the XA error code pertaining to the exception. XA error values are defined in the `javax.transaction.xa.XAException` class; refer to its Javadoc at the Sun Microsystems Web site for more information.

Mapping between Oracle Errors and XA Errors

Oracle errors correspond to XA errors in `OracleXAException` instances as documented in Table 9–2.

Table 9–2 Oracle-XA Error Mapping

Oracle Error Code	XA Error Code
ORA 3113	XAException.XAER_RMFAIL
ORA 3114	XAException.XAER_RMFAIL
ORA 24756	XAException.XAER_NOTA
ORA 24764	XAException.XA_HEURCOM
ORA 24765	XAException.XA_HEURRB
ORA 24766	XAException.XA_HEURMIX
ORA 24767	XAException.XA_RDONLY
ORA 25351	XAException.XA_RETRY
all other ORA errors	XAException.XAER_RMERR

XA Error Handling

The following example uses the `OracleXAException` class to process an XA exception:

```
try {
   ...
   ...Perform XA operations...
   ...
} catch(OracleXAException oxae) {
  int oraerr = oxae.getOracleError();
  System.out.println("Error " + oraerr);
}
  catch(XAException xae)
{...Process generic XA exception...}
```

In case the XA operations did not throw an Oracle-specific XA exception, the code drops through to process a generic XA exception.

Oracle XA Optimizations

Oracle JDBC has functionality to improve performance if two or more branches of a distributed transaction use the same database instance—meaning that the XA resource instances associated with these branches are associated with the same resource manager.

In such a circumstance, the `prepare()` method of only one of these XA resource instances will return `XA_OK` (or failure); the rest will return `XA_RDONLY`, even if updates are made. This allows the transaction manager to implicitly join all the transaction branches and commit (or roll back, if failure) the joined transaction through the XA resource instance that returned `XA_OK` (or failure).

The transaction manager can use the `OracleXAResource` class `isSameRM()` method to determine if two XA resource instances are using the same resource manager. This way it can interpret the meaning of `XA_RDONLY` return values.

Implementing a Distributed Transaction

This section provides an example of how to implement a distributed transaction using Oracle XA functionality.

Summary of Imports for Oracle XA

You must import the following for Oracle XA functionality:

```
import oracle.jdbc.xa.OracleXid;
import oracle.jdbc.xa.OracleXAException;
import oracle.jdbc.pool.*;
import oracle.jdbc.xa.client.*;
import javax.transaction.xa.*;
```

The `oracle.jdbc.pool` package has classes for connection pooling functionality, some of which are subclassed by XA-related classes.

In addition, if the code will run inside an Oracle database and access that database for SQL operations, you must import the following:

```
import oracle.jdbc.xa.server.*;
```

(And if you intend to access *only* the database in which the code runs, you would not need the `oracle.jdbc.xa.client` classes.)

The `client` and `server` packages each have versions of the `OracleXADataSource`, `OracleXAConnection`, and `OracleXAResource` classes. Abstract versions of these three classes are in the top-level `oracle.jdbc.xa` package.

Oracle XA Code Sample

This example uses a two-phase distributed transaction with two transaction branches, each to a separate database.

Note that for simplicity, this example combines code that would typically be in a middle tier with code that would typically be in a transaction manager (such as the XA resource method invocations and the creation of transaction IDs).

For brevity, the specifics of creating transaction IDs (in the `createID()` method) and performing SQL operations (in the `doSomeWork1()` and `doSomeWork2()` methods) are not shown here. The complete example is shipped with the product.

This example executes the following sequence:

1. Start transaction branch #1.
2. Start transaction branch #2.
3. Execute DML operations on branch #1.
4. Execute DML operations on branch #2.
5. End transaction branch #1.
6. End transaction branch #2.
7. Prepare branch #1.
8. Prepare branch #2.
9. Commit branch #1.
10. Commit branch #2.

```
// You need to import the java.sql package to use JDBC
import java.sql.*;
import javax.sql.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.*;
import oracle.jdbc.xa.OracleXid;
import oracle.jdbc.xa.OracleXAException;
import oracle.jdbc.xa.client.*;
import javax.transaction.xa.*;

class XA4
{
  public static void main (String args [])
       throws SQLException
  {

    try
    {
        String URL1 = "jdbc:oracle:oci:@";
        // You can put a database name after the @ sign in the connection URL.
        String URL2 ="jdbc:oracle:thin:@(description=(address=(host=dlsun991)
                     (protocol=tcp)(port=5521))(connect_data=(sid=rdbms2)))";
        // Create first DataSource and get connection
        OracleDataSource ods1 = new OracleDataSource();
        ods1.setURL(URL1);
        ods1.setUser("scott");
        ods1.setPassword("tiger");
        Connection conna = ods1.getConnection();

        // Create second DataSource and get connection
        OracleDataSource ods2 = new OracleDataSource();
        ods2.setURL(URL2);
        ods2.setUser("scott");
        ods2.setPassword("tiger");
        Connection connb = ods2.getConnection();

        // Prepare a statement to create the table
        Statement stmta = conna.createStatement ();

        // Prepare a statement to create the table
        Statement stmtb = connb.createStatement ();

        try
        {
          // Drop the test table
          stmta.execute ("drop table my_table");
        }
        catch (SQLException e)
        {
          // Ignore an error here
        }

        try
        {
          // Create a test table
          stmta.execute ("create table my_table (col1 int)");
        }
        catch (SQLException e)
        {
          // Ignore an error here too
```

```
}

try
{
  // Drop the test table
  stmtb.execute ("drop table my_tab");
}
catch (SQLException e)
{
  // Ignore an error here
}

try
{
  // Create a test table
  stmtb.execute ("create table my_tab (col1 char(30))");
}
catch (SQLException e)
{
  // Ignore an error here too
}

// Create XADataSource instances and set properties.
OracleXADataSource oxds1 = new OracleXADataSource();
oxds1.setURL("jdbc:oracle:oci:@");
oxds1.setUser("scott");
oxds1.setPassword("tiger");

OracleXADataSource oxds2 = new OracleXADataSource();

oxds2.setURL("jdbc:oracle:thin:@(description=(address=(host=dlsun991)
          (protocol=tcp)(port=5521))(connect_data=(sid=rdbms2)))");
oxds2.setUser("scott");
oxds2.setPassword("tiger");

// Get XA connections to the underlying datasources
XAConnection pc1  = oxds1.getXAConnection();
XAConnection pc2  = oxds2.getXAConnection();

// Get the physical connections
Connection conn1 = pc1.getConnection();
Connection conn2 = pc2.getConnection();

// Get the XA resources
XAResource oxar1 = pc1.getXAResource();
XAResource oxar2 = pc2.getXAResource();

// Create the Xids With the Same Global Ids
Xid xid1 = createXid(1);
Xid xid2 = createXid(2);

// Start the Resources
oxar1.start (xid1, XAResource.TMNOFLAGS);
oxar2.start (xid2, XAResource.TMNOFLAGS);

// Execute SQL operations with conn1 and conn2
doSomeWork1 (conn1);
doSomeWork2 (conn2);

// END both the branches -- IMPORTANT
```

```
 oxar1.end(xid1, XAResource.TMSUCCESS);
 oxar2.end(xid2, XAResource.TMSUCCESS);

 // Prepare the RMs
 int prp1 =  oxar1.prepare (xid1);
 int prp2 =  oxar2.prepare (xid2);

 System.out.println("Return value of prepare 1 is " + prp1);
 System.out.println("Return value of prepare 2 is " + prp2);

 boolean do_commit = true;

 if (!((prp1 == XAResource.XA_OK) || (prp1 == XAResource.XA_RDONLY)))
    do_commit = false;

 if (!((prp2 == XAResource.XA_OK) || (prp2 == XAResource.XA_RDONLY)))
    do_commit = false;

System.out.println("do_commit is " + do_commit);
 System.out.println("Is oxar1 same as oxar2 ? " + oxar1.isSameRM(oxar2));

 if (prp1 == XAResource.XA_OK)
   if (do_commit)
      oxar1.commit (xid1, false);
   else
      oxar1.rollback (xid1);

 if (prp2 == XAResource.XA_OK)
   if (do_commit)
      oxar2.commit (xid2, false);
   else
      oxar2.rollback (xid2);

  // Close connections
 conn1.close();
 conn1 = null;
 conn2.close();
 conn2 = null;

 pc1.close();
 pc1 = null;
 pc2.close();
 pc2 = null;

 ResultSet rset = stmta.executeQuery ("select col1 from my_table");
 while (rset.next())
   System.out.println("Col1 is " + rset.getInt(1));

 rset.close();
 rset = null;

 rset = stmtb.executeQuery ("select col1 from my_tab");
 while (rset.next())
   System.out.println("Col1 is " + rset.getString(1));

 rset.close();
 rset = null;

 stmta.close();
 stmta = null;
```

```
        stmtb.close();
        stmtb = null;

        conna.close();
        conna = null;
        connb.close();
        connb = null;

      } catch (SQLException sqe)
      {
        sqe.printStackTrace();
      } catch (XAException xae)
      {
        if (xae instanceof OracleXAException) {
          System.out.println("XA Error is " +
                       ((OracleXAException)xae).getXAError());
          System.out.println("SQL Error is " +
                       ((OracleXAException)xae).getOracleError());
        }
      }
    }

    static Xid createXid(int bids)
      throws XAException
    {...Create transaction IDs...}

    private static void doSomeWork1 (Connection conn)
     throws SQLException
    {...Execute SQL operations...}

    private static void doSomeWork2 (Connection conn)
     throws SQLException
    {...Execute SQL operations...}
}
```

10

Oracle Extensions

Oracle's extensions to the JDBC standard include Java packages and interfaces that let you access and manipulate Oracle datatypes and use Oracle performance extensions. Compared to standard JDBC, the extensions offer you greater flexibility in how you can manipulate the data. This chapter presents an overview of the packages and classes included in Oracle's extensions to standard JDBC. It also describes some of the key support features of the extensions.

This chapter includes these topics:

> **Note:** This chapter focuses on type extensions, as opposed to performance extensions, which are discussed in detail in Chapter 22, "Performance Extensions".

Introduction to Oracle Extensions

Oracle provides two implementations of its JDBC drivers—one that supports Sun Microsystems JDK versions 1.2 and JDK1.3, and one that supports JDK 1.4.

Beyond standard features, Oracle JDBC drivers provide Oracle-specific type extensions and performance extensions.

> **Note:** The JDBC OCI, Thin, and server-side internal drivers support the same functionality and all Oracle extensions.

Both implementations include the following Java packages:

- `oracle.sql` (classes to support all Oracle type extensions)
- `oracle.jdbc` (interfaces to support database access and updates in Oracle type formats)

"Oracle JDBC Packages and Classes" on page 10-5 further describes the preceding packages and their classes.

Support Features of the Oracle Extensions

The Oracle extensions to JDBC include a number of features that enhance your ability to work with Oracle databases. Among these are support for Oracle datatypes, Oracle objects, and specific schema naming.

Support for Oracle Datatypes

A key feature of the Oracle JDBC extensions is the type support in the `oracle.sql` package. This package includes classes that map to all the Oracle SQL datatypes, acting as wrappers for raw SQL data. This functionality provides two significant advantages in manipulating SQL data:

- Accessing data directly in SQL format is sometimes more efficient than first converting it to Java format.
- Performing mathematical manipulations of the data directly in SQL format avoids the loss of precision that occurs in converting between SQL and Java formats.

Once manipulations are complete and it is time to output the information, each of the `oracle.sql.*` type support classes has all the necessary methods to convert data to appropriate Java formats. For a more detailed description of these general issues, see "Package oracle.sql" on page 10-5.

See the following for more information on specific `oracle.sql.*` datatype classes:

- "Oracle Character Datatypes Support" on page 10-19 for information on `oracle.sql.*` character datatypes which includes the SQL CHAR and SQL NCHAR datatypes
- "Additional Oracle Type Extensions" on page 10-23 for information on the `oracle.sql.*` datatype classes for ROWIDs and `REF CURSOR` types
- Chapter 14, "Working with LOBs and BFILEs" for information on `oracle.sql.*` datatype support for BLOBs, CLOBs, and BFILEs
- Chapter 13, "Working with Oracle Object Types" for information on `oracle.sql.*` datatype support for composite data structures (Oracle objects) in the database

- Chapter 15, "Using Oracle Object References" for information on `oracle.sql.*` datatype support for object references
- Chapter 16, "Working with Oracle Collections" for information on `oracle.sql.*` datatype support for collections (VARRAYs and nested tables)

Support for Oracle Objects

Oracle JDBC supports the use of structured objects in the database, where an object datatype is a user-defined type with nested attributes. For example, a user application could define an `Employee` object type, where each `Employee` object has a `firstname` attribute (a character string), a `lastname` attribute (another character string), and an `employeenumber` attribute (integer).

Oracle's JDBC implementation supports Oracle object datatypes. When you work with Oracle object datatypes in a Java application, you must consider the following:

- how to map between Oracle object datatypes and Java classes
- how to store Oracle object attributes in corresponding Java objects (they can be stored in standard Java types or in `oracle.sql.*` types)
- how to convert attribute data between SQL and Java formats
- how to access data

Oracle objects can be mapped either to the weak `java.sql.Struct` or `oracle.sql.STRUCT` types or to strongly typed customized classes. These strong types are referred to as *custom Java classes*, which must implement either the standard `java.sql.SQLData` interface or the Oracle extension `oracle.sql.ORAData` interface. (Chapter 13, "Working with Oracle Object Types" provides more detail regarding these interfaces.) Each interface specifies methods to convert data between SQL and Java.

> **Note:** The `ORAData` interface has replaced the `CustomDatum` interface. While the latter interface is deprecated, it is still supported for backward compatibility.

To create custom Java classes to correspond to your Oracle objects, Oracle recommends that you use the Oracle JPublisher utility to create the classes. To do this, you must define attributes according to how you want to store the data. Oracle JPublisher performs this task seamlessly with command-line options and can generate either `SQLData` or `ORAData` implementations.

For `SQLData` implementations, a *type map* defines the correspondence between Oracle object datatypes and Java classes. Type maps are objects that specify which Java class corresponds to each Oracle object datatype. Oracle JDBC uses these type maps to determine which Java class to instantiate and populate when it retrieves Oracle object data from a result set.

> **Note:** Oracle recommends using the `ORAData` interface, instead of the `SQLData` interface, in situations where portability is not a concern. `ORAData` works more easily and flexibly in conjunction with other features of the Oracle Java platform offerings.

JPublisher automatically defines `getXXX()` methods of the custom Java classes, which retrieve data into your Java application. For more information on the JPublisher utility, see the *Oracle Database JPublisher User's Guide.*

Chapter 13, "Working with Oracle Object Types" describes Oracle JDBC support for Oracle objects.

Support for Schema Naming

Oracle JDBC classes have the ability to accept and return fully qualified schema names. A fully qualified schema name has this syntax:

```
{[schema_name].}[sql_type_name]
```

Where *schema_name* is the name of the schema and *sql_type_name* is the SQL type name of the object. Notice that *schema_name* and *sql_type_name* are separated by a dot (".").

To specify an object type in JDBC, you use its fully qualified name (that is, a schema name and SQL type name). It is not necessary to enter a schema name if the type name is in current naming space (that is, the current schema). Schema naming follows these rules:

- Both the schema name and the type name may or may not be quoted. However, if the SQL type name has a dot in it, such as `CORPORATE.EMPLOYEE`, the type name must be quoted.
- The JDBC driver looks for the first unquoted dot in the object's name and uses the string before the dot as the schema name and the string following the dot as the type name. If no dot is found, the JDBC driver takes the current schema as default. That is, you can specify only the type name (without indicating a schema) instead of specifying the fully qualified name if the object type name belongs to the current schema. This also explains why you must quote the type name if the type name has a dot in it.

  For example, assume that user Scott creates a type called `person.address` and then wants to use it in his session. Scott might want to skip the schema name and pass in `person.address` to the JDBC driver. In this case, if `person.address` is not quoted, then the dot will be detected, and the JDBC driver will mistakenly interpret `person` as the schema name and `address` as the type name.
- JDBC passes the object type name string to the database unchanged. That is, the JDBC driver will not change the character case even if it is quoted.

  For example, if `ScOtT.PersonType` is passed to the JDBC driver as an object type name, the JDBC driver will pass the string to the database unchanged. As another example, if there is white space between characters in the type name string, then the JDBC driver will not remove the white space.

OCI Extensions

See Chapter 19, "JDBC OCI Extensions" for the following OCI driver-specific information:

- OCI Driver Connection Pooling
- OCI Driver Transparent Application Failover
- OCI HeteroRM XA

Oracle JDBC Packages and Classes

This section describes the Java packages that support the Oracle JDBC extensions and the key classes that are included in these packages:

- Package oracle.sql
- Package oracle.jdbc

You can refer to the Oracle JDBC Javadoc for more information about all the classes mentioned in this section.

Package oracle.sql

The `oracle.sql` package supports direct access to data in SQL format. This package consists primarily of classes that provide Java mappings to SQL datatypes.

Essentially, the classes act as Java wrappers for SQL data. The characters are converted to Java chars (in the UCS2 character set), then into bytes in the UCS2 character set.

Each of the `oracle.sql.*` datatype classes extends `oracle.sql.Datum`, a superclass that encapsulates functionality common to all the datatypes. Some of the classes are for JDBC 2.0-compliant datatypes. These classes, as Table 10–1 indicates, implement standard JDBC 2.0 interfaces in the `java.sql` package, as well as extending the `oracle.sql.Datum` class.

Classes of the oracle.sql Package

Table 10–1 lists the `oracle.sql` datatype classes and their corresponding Oracle SQL types.

Table 10–1 Oracle Datatype Classes

Java Class	Oracle SQL Types and Interfaces Implemented
`oracle.sql.STRUCT`	`STRUCT` (objects) implements `java.sql.Struct`)
`oracle.sql.REF`	`REF` (object references) implements `java.sql.Ref`
`oracle.sql.ARRAY`	`VARRAY` or nested table (collections) implements `java.sql.Array`
`oracle.sql.BLOB`	`BLOB` (binary large objects) implements java.sql.Blob
`oracle.sql.CLOB`	SQL `CLOB` (character large objects) and globalization support `NCLOB` datatypes both implement `java.sql.Clob`
`oracle.sql.BFILE`	`BFILE` (external files)
`oracle.sql.CHAR`	`CHAR, NCHAR, VARCHAR2, NVARCHAR2`
`oracle.sql.DATE`	`DATE`
`oracle.sql.TIMESTAMP`	`TIMESTAMP`
`oracle.sql.TIMESTAMPTZ`	`TIMESTAMP WITH TIME ZONE`
`oracle.sql.TIMESTAMPLTZ`	`TIMESTAMP WITH LOCAL TIME ZONE`
`oracle.sql.NUMBER`	`NUMBER`
`oracle.sql.RAW`	`RAW`
`oracle.sql.ROWID`	`ROWID` (row identifiers)
`oracle.sql.OPAQUE`	`OPAQUE`

You can find more detailed information about each of these classes later in this chapter. Additional details about use of the Oracle extended types (`STRUCT`, `REF`, `ARRAY`, `BLOB`, `CLOB`, `BFILE`, and `ROWID`) are described in the following locations:

- "Oracle Character Datatypes Support" on page 10-19
- "Additional Oracle Type Extensions" on page 10-23
- Chapter 14, "Working with LOBs and BFILEs"
- Chapter 13, "Working with Oracle Object Types"
- Chapter 15, "Using Oracle Object References"
- Chapter 16, "Working with Oracle Collections"

Notes:

- For information about retrieving data from a result set or callable statement object into `oracle.sql.*` types, as opposed to Java types, see Chapter 11, "Accessing and Manipulating Oracle Data".
- The `LONG` and `LONG RAW` SQL types and `REF CURSOR` type category have no `oracle.sql.*` classes. Use standard JDBC functionality for these types. For example, retrieve `LONG` or `LONG RAW` data as input streams using the standard JDBC result set and callable statement methods `getBinaryStream()` and `getCharacterStream()`. Use the `getCursor()` method for `REF CURSOR` types.

In addition to the datatype classes, the `oracle.sql` package includes the following support classes and interfaces, primarily for use with objects and collections:

- `oracle.sql.ArrayDescriptor` class: Used in constructing `oracle.sql.ARRAY` objects; describes the SQL type of the array. (See "Creating ARRAY Objects and Descriptors" on page 16-8.)
- `oracle.sql.StructDescriptor` class: Used in constructing `oracle.sql.STRUCT` objects, which you can use as a default mapping to Oracle objects in the database. (See "Creating STRUCT Objects and Descriptors" on page 13-3.)
- `oracle.sql.ORAData` and `oracle.sql.ORADataFactory` interfaces: Used in Java classes implementing the Oracle `ORAData` scenario of Oracle object support. (The other possible scenario is the JDBC-standard `SQLData` implementation.) See "Understanding the ORAData Interface" on page 13-15 for more information on `ORAData`.
- `oracle.sql.OpaqueDescriptor` class: Used to obtain the meta data for an instance of the `oracle.sql.OPAQUE` class.

General oracle.sql.* Datatype Support

Each of the Oracle datatype classes provides, among other things, the following:

- one or more constructors, typically with a constructor that uses raw bytes as input and a constructor that takes a Java type as input
- data storage as Java byte arrays for SQL data

- a `getBytes()` method, which returns the SQL data as a byte array (in the raw format in which JDBC received the data from the database)
- a `toJdbc()` method that converts the data into an object of a corresponding Java class as defined in the JDBC specification

  The JDBC driver does not convert Oracle-specific datatypes that are not part of the JDBC specification, such as `ROWID`; the driver returns the object in the corresponding `oracle.sql.*` format. For example, it returns an Oracle ROWID as an `oracle.sql.ROWID`.
- appropriate `xxxValue()` methods to convert SQL data to Java typed—for example: `stringValue()`, `intValue()`, `booleanValue()`, `dateValue()`, `bigDecimalValue()`
- additional conversion, `getXXX()` and `setXXX()` methods as appropriate for the functionality of the datatype (such as methods in the LOB classes that get the data as a stream, and methods in the `REF` class that get and set object data through the object reference)

Refer to the Oracle JDBC Javadoc for additional information about these classes. See "Class oracle.sql.CHAR" on page 10-21 to learn how the `oracle.sql.CHAR` class supports character data.

Overview of Class oracle.sql.STRUCT

For any given Oracle object type, it is usually desirable to define a custom mapping between SQL and Java. (If you use a `SQLData` custom Java class, the mapping must be defined in a type map.)

If you choose not to define a mapping, however, then data from the object type will be materialized in Java in an instance of the `oracle.sql.STRUCT` class.

The `STRUCT` class implements the standard JDBC 2.0 `java.sql.Struct` interface and extends the `oracle.sql.Datum` class.

In the database, Oracle stores the raw bytes of object data in a linearized form. A `STRUCT` object is a wrapper for the raw bytes of an Oracle object. It contains the SQL type name of the Oracle object and a "values" array of `oracle.sql.Datum` objects that hold the attribute values in SQL format.

You can materialize a STRUCT's attributes as `oracle.sql.Datum[]` objects if you use the `getOracleAttributes()` method, or as `java.lang.Object[]` objects if you use the `getAttributes()` method. Materializing the attributes as `oracle.sql.*` objects gives you all the advantages of the `oracle.sql.*` format:

- Materializing `oracle.sql.STRUCT` data in `oracle.sql.*` format completely preserves data by maintaining it in SQL format. No translation is performed. This is useful if you want to access data but not necessarily display it.
- It allows complete flexibility in how your Java application unpacks data.

Notes:

- Elements of the values array, although of the generic `Datum` type, actually contain data associated with the relevant `oracle.sql.*` type appropriate for the given attribute. You can cast the element to the appropriate `oracle.sql.*` type as desired. For example, a `CHAR` data attribute within the `STRUCT` is materialized as `oracle.sql.Datum`. To use it as `CHAR` data, you must cast it to the `oracle.sql.CHAR` type.
- Nested objects in the values array of a `STRUCT` object are materialized by the JDBC driver as instances of `STRUCT`.

In some cases, you might want to manually create a `STRUCT` object and pass it to a prepared statement or callable statement. To do this, you must also create a `StructDescriptor` object.

For more information about working with Oracle objects using the `oracle.sql.STRUCT` and `StructDescriptor` classes, see "Using the Default STRUCT Class for Oracle Objects" on page 13-2.

Overview of Class oracle.sql.REF

The `oracle.sql.REF` class is the generic class that supports Oracle object references. This class, as with all `oracle.sql.*` datatype classes, is a subclass of the `oracle.sql.Datum` class. It implements the standard JDBC 2.0 `java.sql.Ref` interface.

The `REF` class has methods to retrieve and pass object references. Be aware, however, that selecting an object reference retrieves only a pointer to an object. This does not materialize the object itself. But the `REF` class also includes methods to retrieve and pass the object data.

You cannot create `REF` objects in your JDBC application—you can only retrieve existing `REF` objects from the database.

For more information about working with Oracle object references using the `oracle.sql.REF` class, see Chapter 15, "Using Oracle Object References".

Overview of Class oracle.sql.ARRAY

The `oracle.sql.ARRAY` class supports Oracle collections—either VARRAYs or nested tables. If you select either a VARRAY or nested table from the database, then the JDBC driver materializes it as an object of the `ARRAY` class; the structure of the data is equivalent in either case. The `oracle.sql.ARRAY` class extends `oracle.sql.Datum` and implements the standard JDBC 2.0 `java.sql.Array` interface.

You can use the `setARRAY()` method of the `OraclePreparedStatement` or `OracleCallableStatement` class to pass an array as an input parameter to a prepared statement. Similarly, you might want to manually create an `ARRAY` object to pass it to a prepared statement or callable statement, perhaps to insert into the database. This involves the use of `ArrayDescriptor` objects.

For more information about working with Oracle collections using the `oracle.sql.ARRAY` and `ArrayDescriptor` classes, see "Overview of Collection (Array) Functionality" on page 16-4.

Overview of Classes oracle.sql.BLOB, oracle.sql.CLOB, oracle.sql.BFILE

BLOBs and CLOBs (referred to collectively as "LOBs"), and BFILEs (for external files) are for data items that are too large to store directly in a database table. Instead, the database table stores a locator that points to the location of the actual data.

The `oracle.sql` package supports these datatypes in several ways:

- BLOBs point to large unstructured binary data items and are supported by the `oracle.sql.BLOB` class.
- CLOBs point to large fixed-width character data items (that is, characters that require a fixed number of bytes per character) and are supported by the `oracle.sql.CLOB` class.
- BFILEs point to the content of external files (operating system files) and are supported by the `oracle.sql.BFILE` class.

You can select a BLOB, CLOB, or BFILE locator from the database using a standard `SELECT` statement, but bear in mind that you are receiving only the locator, not the data itself. Additional steps are necessary to retrieve the data.

For information about how to access and manipulate locators and data for LOBs and BFILEs, see Chapter 14, "Working with LOBs and BFILEs".

Classes oracle.sql.DATE, oracle.sql.NUMBER, and oracle.sql.RAW

These classes map to primitive SQL datatypes, which are a part of standard JDBC, and supply conversions to and from the corresponding JDBC Java types. For more information, see the Javadoc.

Because Java `Double` and `Float` `NaN` values do not have an equivalent Oracle `NUMBER` representation, a `NullPointerException` is thrown whenever a `Double.NaN` value or a `Float.NaN` value is converted into an Oracle `NUMBER` using `oracle.sql.NUMBER`, For instance, the following code throws a `NullPointerException`:

```
oracle.sql.NUMBER n = new oracle.sql.NUMBER(Double.NaN);
System.out.println(n.doubleValue());  // throws NullPointerException
```

Classes oracle.sql.TIMESTAMP, oracle.sql.TIMESTAMPTZ, and oracle.sql.TIMESTAMPLTZ

The JDBC drivers support the following date/time datatypes:

- `TIMESTAMP` (`TIMESTAMP`)
- `TIMESTAMP WITH TIME ZONE` (`TIMESTAMPTZ`)
- `TIMESTAMP WITH LOCAL TIME ZONE` (`TIMESTAMPLTZ`)

The JDBC drivers allow conversions among `DATE` and date/time datatypes. For example, you can access a `TIMESTAMP WITH TIME ZONE` column as a `DATE` value.

The JDBC drivers support the most popular time zone names used in the industry as well as most of the time zone names defined in the JDK from Sun Microsystems. Time zones are specified by using the `java.util.Calendar` class.

Note: Do not use `TimeZone.getTimeZone()` to create timezone objects; the Oracle timezone datatypes support more time zone names than does the JDK.

The following code shows how the `TimeZone` and `Calendar` objects are created for `US_PACIFIC`, which is a time zone name not defined in the JDK:

```
TimeZone tz = TimeZone.getDefault();
tz.setID("US_PACIFIC");
GregorianCalendar gcal = new GregorianCalendar(tz);
```

The following Java classes represent the SQL date/time types:

- `oracle.sql.TIMESTAMP`
- `oracle.sql.TIMESTAMPTZ`
- `oracle.sql.TIMESTAMPLTZ`

Use the following methods from the `oracle.jdbc.OraclePreparedStatement` interface to set a date/time:

- `setTIMESTAMP(int paramIdx,TIMESTAMP x)`
- `setTIMESTAMPTZ(int paramIdx,TIMESTAMPTZ x)`
- `setTIMESTAMPLTZ(int paramIdx,TIMESTAMPLTZ x)`

Use the following methods from the `oracle.jdbc.OracleCallableStatement` interface to get a date/time:

- `TIMESTAMP getTIMESTAMP (int paramIdx)`
- `TIMESTAMPTZ getTIMESTAMPTZ(int paramIdx)`
- `TIMESTAMPLTZ getTIMESTAMPLTZ(int paramIdx)`

Use the following methods from the `oracle.jdbc.OracleResultSet` interface to get a date/time:

- `TIMESTAMP getTIMESTAMP(int paramIdx)`
- `TIMESTAMP getTIMESTAMP(java.lang.String colName)`
- `TIMESTAMPTZ getTIMESTAMPTZ(int paramIdx)`
- `TIMESTAMPTZ getTIMESTAMPTZ(java.lang.String colName)`
- `TIMESTAMPLTZ getTIMESTAMPLTZ(int paramIdx)`
- `TIMESTAMPLTZ getTIMESTAMPLTZ(java.lang.String colName)`
- `TIMESTAMPLTZ getTIMESTAMPLTZ(int paramIdx)`

Use the following methods from the `oracle.jdbc.OracleResultSet` interface to update a date/time:

- `updateTIMESTAMP(int paramIdx)`
- `updateTIMESTAMPTZ(int paramIdx)`
- `updateTIMESTAMPLTZ(int paramIdx)`

Before accessing `TIMESTAMP WITH LOCAL TIME ZONE` data, call the `OracleConnection.setSessionTime()` method to set the session time zone. When this method is called, the JDBC driver sets the session time zone of the connection and saves the session time zone so that any `TIMESTAMP WITH LOCAL TIME ZONE` data accessed through JDBC can be adjusted using the session time zone.

Overview of Class oracle.sql.ROWID

This class supports Oracle ROWIDs, which are unique identifiers for rows in database tables. You can select a ROWID as you would select any column of data from the table. Note, however, that you cannot manually update ROWIDs—the Oracle database updates them automatically as appropriate.

The `oracle.sql.ROWID` class does not implement any noteworthy functionality beyond what is in the `oracle.sql.Datum` superclass. However, `ROWID` does provide a `stringValue()` method that overrides the `stringValue()` method in the `oracle.sql.Datum` class and returns the hexadecimal representation of the `ROWID` bytes.

For information about accessing ROWID data, see "Oracle ROWID Type" on page 10-23.

Class oracle.sql.OPAQUE

The `oracle.sql.OPAQUE` class gives you the name and characteristics of the OPAQUE type and any attributes. OPAQUE types provide access only to the uninterrupted bytes of the instance.

> **Note:** There is minimal support for OPAQUE types.

The following are the methods of the `oracle.sql.OPAQUE` class:

- `getBytesValue()`: Returns a byte array that represents the value of the OPAQUE object, in the format used in the database.
- `public boolean isConvertibleTo(Class jClass)`: Determines if a `Datum` object can be converted to a particular class, where `Class` is any class and `jClass` is the class to convert. `true` is returned if conversion to `jClass` is permitted and `false` if conversion to `jClass` is not permitted.
- `getDescriptor()`: Returns the `OpaqueDescriptor` object that contains the type information.
- `getJavaSqlConnection()`: Returns the connection associated with the receiver. Because methods that use the `oracle.jdbc.driver` package are deprecated, the `getConnection()` method has been deprecated in favor of the `getJavaSqlConnection()` method.
- `getSQLTypeName()`: Implements the `java.sql.Struct` interface function and retrieves the SQL type name of the SQL structured type that this `Struct` object represents. This method returns the fully-qualified type name of the SQL structured type which this `STRUCT` object represents.
- `getValue()`: Returns a Java object that represents the value (raw bytes).
- `toJdbc()`: Returns the JDBC representation of the `Datum` object.

Package oracle.jdbc

The interfaces of the `oracle.jdbc` package provide Oracle-specific extensions to allow access to raw SQL format data by using `oracle.sql.*` objects.

For the `oracle.jdbc` package, Table 10–2 lists key interfaces and classes used for connections, statements, and result sets.

Table 10–2 Key Interfaces and Classes of the oracle.jdbc Package

Name	Interface or Class	Key Functionality
`OracleDriver`	Class	implements `java.sql.Driver`
`OracleConnection`	Interface	methods to return Oracle statement objects; methods to set Oracle performance extensions for any statement executed in the current connection (implements `java.sql.Connection`)
`OracleStatement`	Interface	methods to set Oracle performance extensions for individual statement; supertype of `OraclePreparedStatement` and `OracleCallableStatement` (implements `java.sql.Statement`)
`OraclePreparedStatement`	Interface	`setXXX()` methods to bind `oracle.sql.*` types into a prepared statement (implements `java.sql.PreparedStatement`; extends `OracleStatement`; supertypeof `OracleCallableStatement`)
`OracleCallableStatement`	Interface	`getXXX()` methods to retrieve data in `oracle.sql` format; `setXXX()` methods to bind `oracle.sql.*` types into a callable statement (implements `java.sql.CallableStatement`; extends `OraclePreparedStatement`)
`OracleResultSet`	Interface	`getXXX()` methods to retrieve data in `oracle.sql` format (implements `java.sql.ResultSet`)
`OracleResultSetMetaData`	Interface	methods to get meta information about Oracle result sets, such as column names and datatypes (implements `java.sql.ResultSetMetaData`)
`OracleDatabaseMetaData`	Class	methods to get meta information about the database, such as database product name/version, table information, and default transaction isolation level (implements `java.sql.DatabaseMetaData`)
OracleTypes	Class	defines integer constants used to identify SQL types. For standard types, it uses the same values as the standard `java.sql.Types` class. In addition, it adds constants for Oracle extended types.

The remainder of this section describes the interfaces and classes of the `oracle.jdbc` package. For more information about using these interfaces and classes to access Oracle type extensions, see Chapter 11, "Accessing and Manipulating Oracle Data".

Interface oracle.jdbc.OracleConnection

This interface extends standard JDBC connection functionality to create and return Oracle statement objects, set flags and options for Oracle performance extensions, support type maps for Oracle objects, and support client identifiers.

"Additional Oracle Performance Extensions" on page 22-15 describes the performance extensions, including row prefetching and update batching.

Client Identifiers In a connection pooling environment, the client identifier can be used to identify which light-weight user is currently using the database session. A client identifier can also be used to share the Globally Accessed Application Context between different database sessions. The client identifier set in a database session is audited when database auditing is turned on.

> **Note:** See the *Oracle Database Application Developer's Guide - Fundamentals* for a full discussion of Globally Accessed Contexts.

Key methods include:

- `createStatement()`: Allocates a new `OracleStatement` object.
- `prepareStatement()`: Allocates a new `OraclePreparedStatement` object.
- `prepareCall()`: Allocates a new `OracleCallableStatement` object.
- `getTypeMap()`: Retrieves the type map for this connection (for use in mapping Oracle object types to Java classes).
- `setTypeMap()`: Initializes or updates the type map for this connection (for use in mapping Oracle object types to Java classes).
- `getTransactionIsolation()`: Gets this connection's current isolation mode.
- `setTransactionIsolation()`: Changes the transaction isolation level using one of the `TRANSACTION_*` values.

These `oracle.jdbc.OracleConnection` methods are Oracle-defined extensions:

- `setClientIdentifier()`: Sets the client identifier for this connection.
- `clearClientIdentifier()`: Clears the client identifier for this connection.
- `getDefaultExecuteBatch()`: Retrieves the default update-batching value for this connection.
- `setDefaultExecuteBatch()`: Sets the default update-batching value for this connection.
- `getDefaultRowPrefetch()`: Retrieves the default row-prefetch value for this connection.
- `setDefaultRowPrefetch()`: Sets the default row-prefetch value for this connection.

Interface oracle.jdbc.OracleStatement

This interface extends standard JDBC statement functionality and is the superinterface of the `OraclePreparedStatement` and `OracleCallableStatement` classes. Extended functionality includes support for setting flags and options for Oracle performance extensions on a statement-by-statement basis, as opposed to the `OracleConnection` interface that sets these on a connection-wide basis.

"Additional Oracle Performance Extensions" on page 22-15 describes the performance extensions, including row prefetching and column type definitions.

Key methods include:

- `executeQuery()`: Executes a database query and returns an `OracleResultSet` object.
- `getResultSet()`: Retrieves an `OracleResultSet` object.
- `close()`: Closes the current statement.

These `oracle.jdbc.OracleStatement` methods are Oracle-defined extensions:

- `defineColumnType()`: Defines the type you will use to retrieve data from a particular database table column.

  Note: This method is no longer needed or recommended for use with the Thin driver. See the `disableDefineColumnType` connection property in the `oracle.jdbc.pool.OracleDataSource` JavaDoc.

- `getRowPrefetch()`: Retrieves the row-prefetch value for this statement.
- `setRowPrefetch()`: Sets the row-prefetch value for this statement.

Interface oracle.jdbc.OraclePreparedStatement

This interface extends the `OracleStatement` interface and extends standard JDBC prepared statement functionality. Also, the `oracle.jdbc.OraclePreparedStatement` interface is extended by the `OracleCallableStatement` interface. Extended functionality consists of `setXXX()` methods for binding `oracle.sql.*` types and objects into prepared statements, and methods to support Oracle performance extensions on a statement-by-statement basis. "Additional Oracle Performance Extensions" on page 22-15 describes the performance extensions, including database update batching.

Note: Do not use `PreparedStatement` to create a trigger that refers to a `:NEW` or `:OLD` column. Use `Statement` instead; using `PreparedStatement` will cause execution to fail with the message `java.sql.SQLException: Missing IN or OUT parameter at index:: 1`

Key methods include:

- `getExecuteBatch()`: Retrieves the update-batching value for this statement.
- `setExecuteBatch()`: Sets the update-batching value for this statement.
- `setOracleObject()`: This is a generic `setXXX()` method for binding `oracle.sql.*` data into a prepared statement as an `oracle.sql.Datum` object.
- `setXXX()`: These methods, such as `setBLOB()`, are for binding specific `oracle.sql.*` types into prepared statements.
- `setXXXAtName()`: Unlike the JDBC standard method `setXXX(int,XXX)`, which sets the value of the nth SQL parameter specified by the integer argument, `setXXXAtName(String,XXX)` sets the SQL parameter with the specified

character name in the SQL string. The SQL parameter is a SQL identifier preceded by a colon (:). For example, `:id` in

```
ps = conn.prepareStatement("select * from tab where id = :id");
  ((OraclePreparedStatement)ps).setIntByName("id", 42);
```

- `setORAData()`: Binds an `ORAData` object (for use in mapping Oracle object types to Java) into a prepared statement.
- `setNull()`: Sets the value of the object specified by its SQL type name to `NULL`. For `setNull(`*`param_index`*`,` *`type_code`*`,` *`sql_type_name`*`)`, if `type_code` is `REF`, `ARRAY`, or `STRUCT`, then *`sql_type_name`* is the fully qualified name (*`schema.sql_type_name`*) of the SQL type.
- `setFormOfUse()`: Sets which form of use this method is going to use. There are two constants that specify the form of use: `FORM_CHAR` and `FORM_NCHAR`, where `FORM_CHAR` is the default, meaning that the regular database character set is used. If the form of use is set to `FORM_NCHAR`, the JDBC driver will represent the provided data in the national character set of the server. The following code show how the `FORM_NCHAR` is used:

```
pstmt.setFormOfUse
  (parameter index,
  oracle.jdbc.OraclePreparedStatement.FORM_NCHAR)
```

- `close()`: Closes the current statement.

Interface oracle.jdbc.OracleCallableStatement

This interface extends the `OraclePreparedStatement` interface (which extends the `OracleStatement` interface) and incorporates standard JDBC callable statement functionality.

> **Note:** Do not use `CallableStatement` to create a trigger that refers to a `:NEW` or `:OLD` column. Use `Statement` instead; using `CallableStatement` will cause execution to fail with the message `java.sql.SQLException: Missing IN or OUT parameter at index:: 1`

Key methods include:

- `getOracleObject()`: This is a generic `getXXX()` method for retrieving data into an `oracle.sql.Datum` object, which can be cast to the specific `oracle.sql.*` type as necessary.
- `getXXX()`: These methods, such as `getCLOB()`, are for retrieving data into specific `oracle.sql.*` objects.
- `setOracleObject()`: This is a generic `setXXX()` method for binding `oracle.sql.*` data into a callable statement as an `oracle.sql.Datum` object.
- `setXXX()`: These methods, such as `setBLOB()`, are inherited from `OraclePreparedStatement` for binding specific `oracle.sql.*` objects into callable statements.

- `setXXX(String, XXX)`: The definition of a PL/SQL stored procedure may include one or more named parameters. When you create a `CallableStatement` to invoke this stored procedure, you must supply values for all IN parameters. You can either do this with the JDBC standard `setXXX(int,XXX)` methods, or using the Oracle extension `setXXX(String,XXX)` The first argument to this method specifies the name of the PL/SQL formal parameter; the second argument specifies the value. For example, if you have a stored procedure `foo` defined as:

  ```
  CREATE OR REPLACE foo (myparameter VARACHAR2)
    BEGIN
    ...
    END;
  ```

  and you create an `OracleCallableStatement` to invoke `foo`:

  ```
  OracleCallableStatement cs = (OracleCallableStatement)
     conn.prepareCall("call foo(?)");
  ```

  you can pass the string "bar" to this procedure in one of two ways:

  ```
  cs.setString(1,"bar"); // JDBC standard
  // or...
  cs.setString("myparameter","bar"); // Oracle extension
  ```

  > **Note:** The argument is the name of the formal parameter declared in the PL/SQL stored procedure. This name does not necessarily appear anywhere in the SQL string. This differs from the `setXXXatName` method, whose first argument is a substring of the SQL string.

- `setNull()`: Sets the value of the object specified by its SQL type name to `NULL`. For `setNull(`*`param_index`*`,` *`type_code`*`,` *`sql_type_name`*`)`, if *`type_code`* is `REF`, `ARRAY`, or `STRUCT`, then *`sql_type_name`* is the fully qualified (*`schema.type`*) name of the SQL type.
- `setFormOfUse()`: Sets which form of use this method is going to use. There are two constants that specify the form of use: `FORM_CHAR` and `FORM_NCHAR`, where `FORM_CHAR` is the default. If the form of use is set to `FORM_NCHAR`, the JDBC driver will represent the provided data in the national character set of the server. The following code show how `FORM_NCHAR` is used:

```
pstmt.setFormOfUse
  (parameter index,
  oracle.jdbc.OraclePreparedStatement.FORM_NCHAR)
```

- `registerOutParameter()`: Registers the SQL typecode of the statement's output parameter. JDBC requires this for any callable statement with an `OUT` parameter. It takes an integer parameter index (the position of the output variable in the statement, relative to the other parameters) and an integer SQL type (the type constant defined in `oracle.jdbc.OracleTypes`).

  This is an overloaded method. One version of this method is for named types only—when the SQL typecode is `OracleTypes.REF`, `STRUCT`, or `ARRAY`. In this case, in addition to a parameter index and SQL type, the method also takes a `String` SQL type name (the name of the Oracle user-defined type in the database, such as `EMPLOYEE`).

- `close()`: Closes the current result set, if any, and the current statement.

Interface oracle.jdbc.OracleResultSet

This interface extends standard JDBC result set functionality, implementing `getXXX()` methods for retrieving data into `oracle.sql.*` objects.

Key methods include:

- `getOracleObject()`: This is a generic `getXXX()` method for retrieving data into an `oracle.sql.Datum` object. It can be cast to the specific `oracle.sql.*` type as necessary.
- `getXXX()`: These methods, such as `getCLOB()`, are for retrieving data into `oracle.sql.*` objects.

Interface oracle.jdbc.OracleResultSetMetaData

This interface extends standard JDBC result set metadata functionality to retrieve information about Oracle result set objects. See "Using Result Set Meta Data Extensions" on page 11-13 for information on the functionality of the `OracleResultSetMetadata` interface.

Class oracle.jdbc.OracleTypes

The `OracleTypes` class defines constants that JDBC uses to identify SQL types. Each variable in this class has a constant integer value. The `oracle.jdbc.OracleTypes` class duplicates the typecode definitions of the standard Java `java.sql.Types` class and contains these additional typecodes for Oracle extensions:

- `OracleTypes.BFILE`
- `OracleTypes.ROWID`
- `OracleTypes.CURSOR` (for `REF CURSOR` types)

As in `java.sql.Types`, all the variable names are in all-caps.

JDBC uses the SQL types identified by the elements of the `OracleTypes` class in two main areas: registering output parameters, and in the `setNull()` method of the `PreparedStatement` class.

OracleTypes and Registering Output Parameters The typecodes in `java.sql.Types` or `oracle.jdbc.OracleTypes` identify the SQL types of the output parameters in the `registerOutParameter()` method of the `java.sql.CallableStatement` interface and `oracle.jdbc.OracleCallableStatement` interface.

These are the forms that `registerOutputParameter()` can take for `CallableStatement` and `OracleCallableStatement` (assume a standard callable statement object `cs`):

```
cs.registerOutParameter(int index, int sqlType);

cs.registerOutParameter(int index, int sqlType, String sql_name);

cs.registerOutParameter(int index, int sqlType, int scale);
```

In these signatures, *`index`* represents the parameter index, *`sqlType`* is the typecode for the SQL datatype, *`sql_name`* is the name given to the datatype (for user-defined types, when *`sqlType`* is a `STRUCT`, `REF`, or `ARRAY` typecode), and *`scale`* represents the number of digits to the right of the decimal point (when *`sqlType`* is a `NUMERIC` or `DECIMAL` typecode).

The following example uses a CallableStatement to call a procedure named charout, which returns a CHAR datatype. Note the use of the OracleTypes.CHAR typecode in the registerOutParameter() method (although java.sql.Types.CHAR could have been used as well).

```
CallableStatement cs = conn.prepareCall ("BEGIN charout (?); END;");
cs.registerOutParameter (1, OracleTypes.CHAR);
cs.execute ();
System.out.println ("Out argument is: " + cs.getString (1));
```

The next example uses a CallableStatement to call structout, which returns a STRUCT datatype. The form of registerOutParameter() requires you to specify the typecode (Types.STRUCT or OracleTypes.STRUCT), as well as the SQL name (EMPLOYEE).

The example assumes that no type mapping has been declared for the EMPLOYEE type, so it is retrieved into a STRUCT datatype. To retrieve the value of EMPLOYEE as an oracle.sql.STRUCT object, the statement object cs is cast to an OracleCallableStatement and the Oracle extension getSTRUCT() method is invoked.

```
CallableStatement cs = conn.prepareCall ("BEGIN structout (?); END;");
cs.registerOutParameter (1, OracleTypes.STRUCT, "EMPLOYEE");
cs.execute ();

// get the value into a STRUCT because it
// is assumed that no type map has been defined
STRUCT emp = ((OracleCallableStatement)cs).getSTRUCT (1);
```

OracleTypes and the setNull() Method The typecodes in Types and OracleTypes identify the SQL type of the data item, which the setNull() method sets to NULL. The setNull() method can be found in the java.sql.PreparedStatement interface and the oracle.jdbc.OraclePreparedStatement interface.

These are the forms that setNull() can take for PreparedStatement and OraclePreparedStatement objects (assume a standard prepared statement object ps):

```
ps.setNull(int index, int sqlType);

ps.setNull(int index, int sqlType, String sql_name);
```

In these signatures, *index* represents the parameter index, *sqlType* is the typecode for the SQL datatype, and *sql_name* is the name given to the datatype (for user-defined types, when *sqlType* is a STRUCT, REF, or ARRAY typecode). If you enter an invalid *sqlType*, a Parameter Type Conflict exception is thrown.

The following example uses a PreparedStatement to insert a NULL numeric value into the database. Note the use of OracleTypes.NUMERIC to identify the numeric object set to NULL (although Types.NUMERIC could have been used as well).

```
PreparedStatement pstmt =
    conn.prepareStatement ("INSERT INTO num_table VALUES (?)");

pstmt.setNull (1, OracleTypes.NUMERIC);
pstmt.execute ();
```

In this example, the prepared statement inserts a NULL STRUCT object of type EMPLOYEE into the database.

```
PreparedStatement pstmt = conn.prepareStatement
```

```
                                ("INSERT INTO employee_table VALUES (?)");

pstmt.setNull (1, OracleTypes.STRUCT, "EMPLOYEE");
pstmt.execute ();
```

Method getJavaSqlConnection()

The `getJavaSqlConnection()` method of the oracle.sql.* classes returns `java.sql.Connection` while the `getConnection()` method returns `oracle.jdbc.driver.OracleConnection`. Because the methods that use the `oracle.jdbc.driver` package are deprecated, the `getConnection()` method is also deprecated in favor of the `getJavaSqlConnection()` method.

For the following Oracle datatype classes, the `getJavaSqlConnection()` method is available:

- `oracle.sql.ARRAY`
- `oracle.sql.BFILE`
- `oracle.sql.BLOB`
- `oracle.sql.CLOB`
- `oracle.sql.OPAQUE`
- `oracle.sql.REF`
- `oracle.sql.STRUCT`

The following shows the `getJavaSqlConnection()` and the `getConnection()` methods in the `Array` class:

```
public class ARRAY
{
  // New API
  //
  java.sql.Connection getJavaSqlConnection()
    throws SQLException;

  // Deprecated API.
  //
  oracle.jdbc.driver.OracleConnection
    getConnection() throws SQLException;

  ...
}
```

Oracle Character Datatypes Support

Oracle character datatypes include the SQL CHAR and SQL NCHAR datatypes. The following sections describe how these datatypes can be accessed using the Oracle JDBC drivers.

SQL CHAR Datatypes

The SQL CHAR datatypes include `CHAR`, `VARCHAR2`, and `CLOB`. These datatypes allow you to store character data in the database character set encoding scheme. The character set of the database is established when you create the database.

SQL NCHAR Datatypes

SQL NCHAR datatypes were created for Globalization Support (formerly NLS). SQL NCHAR datatypes include `NCHAR`, `NVARCHAR2`, and `NCLOB`. These datatypes allow you to store Unicode data in the database NCHAR character set encoding. The NCHAR character set, which never changes, is established when you create the database. See the *Oracle Database Globalization Support Guide* for information on SQL NCHAR datatypes.

> **Note:** Because the `UnicodeStream` class is deprecated in favor of the `CharacterStream` class, the `setUnicodeStream()` and `getUnicodeStream()` methods are not supported for NCHAR datatype access. Use the `setCharacterStream()` method and the `getCharacterStream()` method if you want to use stream access.

The usage of SQL NCHAR datatypes is similar to that of the SQL CHAR (`CHAR`, `VARCHAR2`, and `CLOB`) datatypes. JDBC uses the same classes and methods to access SQL NCHAR datatypes that are used for the corresponding SQL CHAR datatypes. Therefore, there are no separate, corresponding classes defined in the `oracle.sql` package for SQL NCHAR datatypes. Likewise, there is no separate, corresponding constant defined in the `oracle.jdbc.OracleTypes` class for SQL NCHAR datatypes. The only difference in usage between the two datatypes occur in a data bind situation: a JDBC program must call the `setFormOfUse()` method to specify if the data is bound for a SQL NCHAR datatype.

> **Note:** The `setFormOfUse()` method must be called before the `registerOutParameter()` method is called in order to avoid unpredictable results.

The following code shows how to access SQL NCHAR data:

```
//
// Table TEST has the following columns:
// - NUMBER
// - NVARCHAR2
// - NCHAR
//
oracle.jdbc.OraclePreparedStatement pstmt =
  (oracle.jdbc.OraclePreparedStatement)
conn.prepareStatement("insert into TEST values(?, ?, ?)");

//
// oracle.jdbc.OraclePreparedStatement.FORM_NCHAR should be used for all NCHAR,
// NVARCHAR2 and NCLOB data types.
//
pstmt.setFormOfUse(2, OraclePreparedStatement.FORM_NCHAR);
pstmt.setFormOfUse(3, OraclePreparedStatement.FORM_NCHAR);

pstmt.setInt(1, 1);                    // NUMBER column
pstmt.setString(2, myUnicodeString1);  // NVARCHAR2 column
pstmt.setString(3, myUnicodeString2);  // NCHAR column
pstmt.execute();
OraclePreparedStatement.FORM_NCHAR
```

Class oracle.sql.CHAR

The CHAR class is used by Oracle JDBC in handling and converting character data. The JDBC driver constructs and populates oracle.sql.CHAR objects once character data has been read from the database.

> **Note:** The oracle.sql.CHAR class is used for both SQL CHAR and SQL NCHAR datatypes.

The CHAR objects constructed and returned by the JDBC driver can be in the database character set, UTF-8, or ISO-Latin-1 (WE8ISO8859P1). The CHAR objects that are Oracle object attributes are returned in the database character set.

JDBC application code rarely needs to construct CHAR objects directly, since the JDBC driver automatically creates CHAR objects as character data are obtained from the database. There may be circumstances, however, where constructing CHAR objects directly in application code is useful—for example, to repeatedly pass the same character data to one or more prepared statements without the overhead of converting from Java strings each time.

oracle.sql.CHAR Objects and Character Sets

The CHAR class provides Globalization Support functionality to convert character data. This class has two key attributes: (1) Globalization Support character set and (2) the character data. The Globalization Support character set defines the encoding of the character data. It is a parameter that is always passed when a CHAR object is constructed. Without the Globalization Support character set being know, the bytes of data in the CHAR object are meaningless.

The oracle.sql.CharacterSet class is instantiated to represent character sets. To construct a CHAR object, you must provide character set information to the CHAR object by way of an instance of the CharacterSet class. Each instance of this class represents one of the Globalization Support character sets that Oracle supports. A CharacterSet instance encapsulates methods and attributes of the character set, mainly involving functionality to convert to or from other character sets. You can find a complete list of the character sets that Oracle supports in the *Oracle Database Globalization Support Guide*.

Constructing an oracle.sql.CHAR Object

Follow these general steps to construct a CHAR object:

1. Create a CharacterSet object by calling the static CharacterSet.make() method.

   This method is a factory for the character set instance. The make() method takes an integer as input, which corresponds to a character set ID that Oracle supports. For example:

   ```
   int oracleId = CharacterSet.JA16SJIS_CHARSET; // this is character set ID,
                                                 // 832
   ...
   CharacterSet mycharset = CharacterSet.make(oracleId);
   ```

   Each character set that Oracle supports has a unique, predefined Oracle ID.

   For more information on character sets and character set IDs, see the *Oracle Database Globalization Support Guide*.

2. Construct a CHAR object.

   Pass a string (or the bytes that represent the string) to the constructor along with the CharacterSet object that indicates how to interpret the bytes based on the character set. For example:

```
String mystring = "teststring";
...
CHAR mychar = new CHAR(teststring, mycharset);
```

   The CHAR class has multiple constructors—they can take a string, a byte array, or an object as input along with the CharacterSet object. In the case of a string, the string is converted to the character set indicated by the CharacterSet object before being placed into the CHAR object.

   See the oracle.sql.CHAR class Javadoc for more information.

Notes:

- The CharacterSet object cannot be null.
- The CharacterSet class is an abstract class, therefore it has no constructor. The only way to create instances is to use the make() method.
- The server recognizes the special value CharacterSet.DEFAULT_CHARSET as the database character set. For the client, this value is not meaningful.
- Oracle does not intend or recommend that users extend the CharacterSet class.

---

oracle.sql.CHAR Conversion Methods

The CHAR class provides the following methods for translating character data to strings:

- getString(): Converts the sequence of characters represented by the CHAR object to a string, returning a Java String object. If you enter an invalid OracleID, then the character set will not be recognized and the getString() method throws a SQLException.
- toString(): Identical to the getString() method. But if you enter an invalid OracleID, then the character set will not be recognized and the toString() method returns a hexadecimal representation of the CHAR data and does *not* throw a SQLException.
- getStringWithReplacement(): Identical to getString(), except a default replacement character replaces characters that have no unicode representation in the CHAR object character set. This default character varies from character set to character set, but is often a question mark ("?").

The server (a database) and the client, or application running on the client, can use different character sets. When you use the methods of the CHAR class to transfer data between the server and the client, the JDBC drivers must convert the data from the server character set to the client character set or vice versa. To convert the data, the drivers use Globalization Support. For more information on how the JDBC drivers convert between character sets, see Chapter 12, "Globalization Support".

Additional Oracle Type Extensions

See other chapters in this book for information about key Oracle type extensions:

- Chapter 14, "Working with LOBs and BFILEs"
- Chapter 13, "Working with Oracle Object Types"
- Chapter 15, "Using Oracle Object References"
- Chapter 16, "Working with Oracle Collections"

This section covers additional Oracle type extensions. Oracle JDBC drivers support the Oracle-specific `BFILE` and `ROWID` datatypes and `REF CURSOR` types, which are not part of the standard JDBC specification. This section describes the `ROWID` and `REF CURSOR` type extensions. See Chapter 14 for information about BFILEs.

`ROWID` is supported as a Java string, and `REF CURSOR` types are supported as JDBC result sets.

Oracle ROWID Type

A ROWID is an identification tag unique for each row of an Oracle database table. The ROWID can be thought of as a virtual column, containing the ID for each row.

The `oracle.sql.ROWID` class is supplied as a wrapper for type `ROWID` SQL data.

ROWIDs provide functionality similar to the `getCursorName()` method specified in the `java.sql.ResultSet` interface, and the `setCursorName()` method specified in the `java.sql.Statement` interface.

If you include the ROWID pseudo-column in a query, then you can retrieve the ROWIDs with the result set `getString()` method (passing in either the column index or the column name). You can also bind a ROWID to a `PreparedStatement` parameter with the `setString()` method. This allows in-place updates, as in the example that follows.

> **Note:** The `oracle.sql.ROWID` class replaces `oracle.jdbc.driver.ROWID`, which was used in previous releases of Oracle JDBC.

Example: ROWID

The following example shows how to access and manipulate `ROWID` data.

```
Statement stmt = conn.createStatement();

// Query the employee names with "FOR UPDATE" to lock the rows.
// Select the ROWID to identify the rows to be updated.

ResultSet rset =
   stmt.executeQuery ("SELECT ename, rowid FROM emp FOR UPDATE");

// Prepare a statement to update the ENAME column at a given ROWID

PreparedStatement pstmt =
   conn.prepareStatement ("UPDATE emp SET ename = ? WHERE rowid = ?");

// Loop through the results of the query
while (rset.next ())
{
```

```
    String ename = rset.getString (1);
    oracle.sql.ROWID rowid = rset.getROWID (2);  // Get the ROWID as a String
    pstmt.setString (1, ename.toLowerCase ());
    pstmt.setROWID (2, rowid); // Pass ROWID to the update statement
    pstmt.executeUpdate ();     // Do the update
}
```

Oracle REF CURSOR Type Category

A cursor variable holds the memory location (address) of a query work area, rather than the contents of the area. Declaring a cursor variable creates a pointer. In SQL, a pointer has the datatype `REF x`, where `REF` is short for `REFERENCE` and *x* represents the entity being referenced. A REF CURSOR, then, identifies a reference to a cursor variable. Because many cursor variables might exist to point to many work areas, `REF CURSOR` can be thought of as a category or "datatype specifier" that identifies many different types of cursor variables.

> **Note:** `REF CURSOR` instances are not scrollable.

To create a cursor variable, begin by identifying a type that belongs to the `REF CURSOR` category. For example:

```
DECLARE TYPE DeptCursorTyp IS REF CURSOR
```

Then create the cursor variable by declaring it to be of the type `DeptCursorTyp`:

```
dept_cv DeptCursorTyp  - - declare cursor variable
...
```

`REF CURSOR`, then, is a *category* of datatypes, rather than a particular datatype.

Stored procedures can return cursor variables of the `REF CURSOR` category. This output is equivalent to a database cursor or a JDBC result set. A REF CURSOR essentially encapsulates the results of a query.

In JDBC, REF CURSORs are materialized as `ResultSet` objects and can be accessed as follows:

1. Use a JDBC callable statement to call a stored procedure. It must be a callable statement, as opposed to a prepared statement, because there is an output parameter.
2. The stored procedure returns a REF CURSOR.
3. The Java application casts the callable statement to an Oracle callable statement and uses the `getCursor()` method of the `OracleCallableStatement` class to materialize the REF CURSOR as a JDBC `ResultSet` object.
4. The result set is processed as requested.

> **Important:** The cursor associated with a REF CURSOR is closed whenever the statement object that produced the REF CURSOR is closed.
>
> Unlike in past releases, the cursor associated with a REF CURSOR is *not* closed when the result set object in which the REF CURSOR was materialized is closed.

Example: Accessing REF CURSOR Data

This example shows how to access REF CURSOR data.

```
import oracle.jdbc.*;
...
CallableStatement cstmt;
ResultSet cursor;

// Use a PL/SQL block to open the cursor
cstmt = conn.prepareCall
         ("begin open ? for select ename from emp; end;");

cstmt.registerOutParameter(1, OracleTypes.CURSOR);
cstmt.execute();
cursor = ((OracleCallableStatement)cstmt).getCursor(1);

// Use the cursor like a normal ResultSet
while (cursor.next ())
    {System.out.println (cursor.getString(1));}
```

In the preceding example:

- A `CallableStatement` object is created by using the `prepareCall()` method of the connection class.
- The callable statement implements a PL/SQL procedure that returns a REF CURSOR.
- As always, the output parameter of the callable statement must be registered to define its type. Use the typecode `OracleTypes.CURSOR` for a REF CURSOR.
- The callable statement is executed, returning the REF CURSOR.
- The `CallableStatement` object is cast to an `OracleCallableStatement` object to use the `getCursor()` method, which is an Oracle extension to the standard JDBC API, and returns the REF CURSOR into a `ResultSet` object.

11

Accessing and Manipulating Oracle Data

This chapter describes data access in `oracle.sql.*` formats, as opposed to standard Java formats. As described in the previous chapter, the `oracle.sql.*` formats are a key factor of the Oracle JDBC extensions, offering significant advantages in efficiency and precision in manipulating SQL data.

Using `oracle.sql.*` formats involves casting your result sets and statements to `OracleResultSet`, `OracleStatement`, `OraclePreparedStatement`, and `OracleCallableStatement` objects, as appropriate, and using the `getOracleObject()`, `setOracleObject()`, `getXXX()`, and `setXXX()` methods of these classes (where `XXX` corresponds to the types in the `oracle.sql` package).

This chapter covers the following topics:

Data Conversion Considerations

When JDBC programs retrieve SQL data into Java, you can use standard Java types, or you can use types of the `oracle.sql` package.

Standard Types Versus Oracle Types

In processing speed and effort, the `oracle.sql.*` classes usually provide the most efficient way of representing SQL data. These classes store the usual representations of SQL data as byte arrays. They do not reformat the data.

In Oracle 10g, the implementation of the JDBC drivers has been changed in order to improve overall performance. As a result, all character data is converted to Java `chars`, which are in the UCS2 character set. A result of this is that `oracle.sql.CHAR` is no longer the most efficient way to access character data. In order to construct a `CHAR`, JDBC must convert the Java chars to bytes encoded in the appropriate character set. This additional conversion causes a reduction in performance. At this release, unlike earlier versions, the most efficient way to access character data in JDBC is through the Java type 3. It is worth noting that the `NUMBER`, `DATE` and other conversions are much faster in 10*g* Release 1 (10.1) and the performance advantage of using the oracle.sql types is correspondingly less.

Converting SQL NULL Data

Java represents a SQL `NULL` datum by the Java value `null`. Java datatypes fall into two categories: primitive types (such as `byte`, `int`, `float`) and object types (class instances). The primitive types cannot represent `null`. Instead, they store the null as the value zero (as defined by the JDBC specification). This can lead to ambiguity when you try to interpret your results.

In contrast, Java object types can represent `null`. The Java language defines an object wrapper type corresponding to every primitive type (for example, `Integer` for `int`, `Float` for `float`) that can represent `null`. The object wrapper types must be used as the targets for SQL data to detect SQL `NULL` without ambiguity.

Testing for NULLs

You cannot use a relational operator to compare `NULL` values with each other or with other values. For example, the following `SELECT` statement fails if the `COMM` column contains one or more `NULL`s. This `SELECT` does not return any rows.

```
PreparedStatement pstmt = conn.prepareStatement(
  "SELECT * FROM EMP WHERE COMM = ?");
pstmt.setNull(1, java.sql.Types.VARCHAR);
```

The next example shows how to compare values for equality when some return values might be `NULL`. The following code returns all the `ENAMES` from the `EMP` table that are `NULL`, if there is no value of 100 for `COMM`.

```
PreparedStatement pstmt = conn.prepareStatement("SELECT ENAME FROM EMP
  WHERE COMM =? OR  ((COMM IS NULL) AND (? IS NULL))");
pstmt.setBigDecimal(1, new BigDecimal(100));
pstmt.setNull(2, java.sql.Types.VARCHAR);
```

Result Set and Statement Extensions

The JDBC `Statement` object returns an `OracleResultSet` object, typed as a `java.sql.ResultSet`. If you want to apply only standard JDBC methods to the object, keep it as a `ResultSet` type. However, if you want to use the Oracle extensions on the object, you must cast it to an `OracleResultSet` type. Although the type by which the Java compiler will identify the object is changed, the object itself is unchanged. All of the Oracle `ResultSet` extensions are in the class

oracle.jdbc.OracleResultSet; all the Statement extensions are in the class oracle.jdbc.OracleStatement.

For example, assuming you have a standard Statement object stmt, do the following if you want to use only standard JDBC ResultSet methods:

```
ResultSet rs = stmt.executeQuery("SELECT * FROM emp");
```

If you need the extended functionality provided by the Oracle extensions to JDBC, you can select the results into a standard ResultSet variable, as above, and then cast that variable to OracleResultSet later.

Similarly, when you use executeQuery() to execute a stored procedure using a callable statement, the returned object is an OracleCallableStatement. The type of the return value of executeQuery() is java.sql.CallableStatement. If your application needs only the standard JDBC methods, you need not cast the variable. However, to take advantage of the Oracle extensions, you must cast the variable to an OracleCallableStatement type. Although the type by which the Java compiler identifies the object is changed, the object itself is unchanged. Similar rules apply to prepareStatement(), prepareCall(), and so on.

Key extensions to the result set and statement classes include the getOracleObject() and setOracleObject() methods, used to access and manipulate data in oracle.sql.* formats. For more information, see the next section: "Comparison of Oracle get and set Methods to Standard JDBC".

Comparison of Oracle get and set Methods to Standard JDBC

This section describes get and set methods, particularly the JDBC standard getObject() and setObject() methods and the Oracle-specific getOracleObject() and setOracleObject() methods, and how to access data in oracle.sql.* format compared with Java format.

Although there are specific getXXX() methods for all the Oracle SQL types (as described in "Other getXXX() Methods" on page 11-6), you can use the general get methods for convenience or simplicity, or if you are not certain in advance what type of data you will receive.

Standard getObject() Method

The standard JDBC getObject() method of a result set or callable statement has a return type of java.lang.Object. The class of the object returned is based on its SQL type, as follows:

- For SQL datatypes that are not Oracle-specific, getObject() returns the default Java type corresponding to the column's SQL type, following the mapping in the JDBC specification.
- For Oracle-specific datatypes (such as ROWID, discussed in "Oracle ROWID Type" on page 10-23), getObject() returns an object of the appropriate oracle.sql.* class (such as oracle.sql.ROWID).

- For Oracle database objects, `getObject()` returns a Java object of the class specified in your type map. Type maps specify a mapping from database named types to Java classes; they are discussed in "Understanding Type Maps for SQLData Implementations" on page 13-8. The `getObject(parameter_index)` method uses the connection's default type map. The `getObject(parameter_index, map)` enables you to pass in a type map. If the type map does not provide a mapping for a particular Oracle object, then `getObject()` returns an `oracle.sql.STRUCT` object.

For more information on `getObject()` return types, see Table 11–1, " getObject() and getOracleObject() Return Types" on page 11-5.

Oracle getOracleObject() Method

If you want to retrieve data from a result set or callable statement as an `oracle.sql.*` object, you must follow a special process. For a `ResultSet`, you must cast the result set itself to `oracle.sql.OracleResultSet` and then invoke `getOracleObject()` instead of `getObject()`. The same applies to `CallableStatement` and `oracle.sql.OracleCallableStatement`.

The return type of `getOracleObject()` is `oracle.sql.Datum`. The actual returned object is an instance of the appropriate `oracle.sql.*` class (the `oracle.sql.*` classes extend `Datum`). The method signature is:

```
public oracle.sql.Datum getOracleObject(int parameter_index)
```

When you retrieve data into a `Datum` variable, you can use the standard Java `instanceof` operator to determine which `oracle.sql.*` type it really is.

For more information on `getOracleObject()` return values, see Table 11–1, " getObject() and getOracleObject() Return Types" on page 11-5.

Example: Using getOracleObject() with a ResultSet

The following example creates a table that contains a column of `CHAR` data and a column containing a `BFILE` locator. A `SELECT` statement retrieves the contents of the table as a result set. The `getOracleObject()` then retrieves the `CHAR` data into the `char_datum` variable and the `BFILE` locator into the `bfile_datum` variable. Note that because `getOracleObject()` returns a `Datum` object, the return values must be cast to `CHAR` and `BFILE`, respectively.

```
stmt.execute ("CREATE TABLE bfile_table (x varchar2 (30), b bfile)");
stmt.execute
    ("INSERT INTO bfile_table VALUES ('one', bfilename ('TEST_DIR', 'file1'))");

ResultSet rset = stmt.executeQuery ("SELECT * FROM bfile_table");
while (rset.next ())
{
   CHAR char_datum = (CHAR) ((OracleResultSet)rset).getOracleObject (1);
   BFILE bfile_datum = (BFILE) ((OracleResultSet)rset).getOracleObject (2);
   ...
}
```

Example: Using getOracleObject() in a Callable Statement

The following example prepares a call to the procedure `myGetDate()`, which associates a character string with a date. The program passes `"SCOTT"` to the prepared call and registers the `DATE` type as an output parameter. After the call is executed, `getOracleObject()` retrieves the date associated with `"SCOTT"`. Note that because `getOracleObject()` returns a `Datum` object, the results are cast to `DATE`.

```
OracleCallableStatement cstmt = (OracleCallableStatement)conn.prepareCall
                                    ("begin myGetDate (?, ?); end;");

cstmt.setString (1, "SCOTT");
cstmt.registerOutParameter (2, Types.DATE);
cstmt.execute ();

DATE date = (DATE) ((OracleCallableStatement)cstmt).getOracleObject (2);
...
```

Summary of getObject() and getOracleObject() Return Types

Table 11–1 summarizes the information in the preceding sections, "Standard getObject() Method" and "Oracle getOracleObject() Method" on page 11-4.

This table lists the underlying return types for each method for each Oracle SQL type, but keep in mind the signatures of the methods when you write your code:

- `getObject()`: Always returns data into a `java.lang.Object` instance.
- `getOracleObject()`: Always returns data into an `oracle.sql.Datum` instance.

You must cast the returned object to use any special functionality (see "Datatypes For Returned Objects from getObject and getXXX" on page 11-8).

Table 11–1 getObject() and getOracleObject() Return Types

Oracle SQL Type	getObject() Underlying Return Type	getOracleObject() Underlying Return Type
CHAR	String	oracle.sql.CHAR
VARCHAR2	String	oracle.sql.CHAR
LONG	String	oracle.sql.CHAR
NUMBER	java.math.BigDecimal or java.lang.Double if j2eeCompliant flag is set to true	oracle.sql.NUMBER
RAW	byte[]	oracle.sql.RAW
LONGRAW	byte[]	oracle.sql.RAW
DATE	java.sql.Date	oracle.sql.DATE
TIMESTAMP	java.sql.Timestamp	oracle.sql.TIMESTAMP
ROWID	oracle.sql.ROWID	oracle.sql.ROWID
REF CURSOR	java.sql.ResultSet	(not supported)
BLOB	oracle.sql.BLOB	oracle.sql.BLOB
CLOB	oracle.sql.CLOB	oracle.sql.CLOB
BFILE	oracle.sql.BFILE	oracle.sql.BFILE
Oracle object	class specified in type map or oracle.sql.STRUCT (if no type map entry)	oracle.sql.STRUCT
Oracle object reference	oracle.sql.REF	oracle.sql.REF

Table 11–1 (Cont.) getObject() and getOracleObject() Return Types

Oracle SQL Type	getObject() Underlying Return Type	getOracleObject() Underlying Return Type
collection (varray or nested table)	`oracle.sql.ARRAY`	`oracle.sql.ARRAY`

For information on type compatibility between all SQL and Java types, see Table 24–1, " Valid SQL Datatype-Java Class Mappings" on page 24-1.

Other getXXX() Methods

Standard JDBC provides a `getXXX()` for each standard Java type, such as `getByte()`, `getInt()`, `getFloat()`, and so on. Each of these returns exactly what the method name implies (a `byte`, an `int`, a `float`, and so on).

In addition, the `OracleResultSet` and `OracleCallableStatement` classes provide a full complement of `getXXX()` methods corresponding to all the `oracle.sql.*` types. Each `getXXX()` method returns an `oracle.sql.XXX` object. For example, `getROWID()` returns an `oracle.sql.ROWID` object.

There is no performance advantage in using the specific `getXXX()` methods; they do save you the trouble of casting, because the return type is specific to the object being returned.

Return Types of getXXX() Methods

Table 11–2 summarizes the return types for each `getXXX()` method, and notes which are Oracle extensions under JDK 1.2.x. You must cast to an `OracleResultSet` or `OracleCallableStatement` to use methods that are Oracle extensions.

Table 11–2 Summary of getXXX() Return Types

Method	Return Type (type in method signature)	Class of returned object	Oracle Ext for JDK 1.2.x?
`getArray()`	`java.sql.Array`	`oracle.sql.ARRAY`	No
`getARRAY()`	`oracle.sql.ARRAY`	`oracle.sql.ARRAY`	Yes
`getAsciiStream()`	`java.io.InputStream`	`java.io.InputStream`	No
`getBfile()`	`oracle.sql.BFILE`	`oracle.sql.BFILE`	Yes
`getBFILE()`	`oracle.sql.BFILE`	`oracle.sql.BFILE`	Yes
`getBigDecimal()` (see Notes section below)	`java.math.BigDecimal`	`java.math.BigDecimal`	No
`getBinaryStream()`	`java.io.InputStream`	`java.io.InputStream`	No
`getBlob()`	`java.sql.Blob`	`oracle.sql.BLOB`	No
`getBLOB`	`oracle.sql.BLOB`	`oracle.sql.BLOB`	Yes
`getBoolean()` (see Notes section below)	`boolean`	`boolean`	No
`getByte()`	`byte`	`byte`	No

Table 11–2 (Cont.) Summary of getXXX() Return Types

Method	Return Type (type in method signature)	Class of returned object	Oracle Ext for JDK 1.2.x?
getBytes()	byte[]	byte[]	No
getCHAR()	oracle.sql.CHAR	oracle.sql.CHAR	Yes
getCharacterStream()	java.io.Reader	java.io.Reader	No
getClob()	java.sql.Clob	oracle.sql.CLOB	No
getCLOB()	oracle.sql.CLOB	oracle.sql.CLOB	Yes
getDate()	java.sql.Date	java.sql.Date	No
getDATE()	oracle.sql.DATE	oracle.sql.DATE	Yes
getDouble()	double	double	No
getFloat()	float	float	No
getInt()	int	int	No
getLong()	long	long	No
getNUMBER()	oracle.sql.NUMBER	oracle.sql.NUMBER	Yes
getOracleObject()	oracle.sql.Datum	subclasses of oracle.sql.Datum	Yes
getRAW()	oracle.sql.RAW	oracle.sql.RAW	Yes
getRef()	java.sql.Ref	oracle.sql.REF	No
getREF()	oracle.sql.REF	oracle.sql.REF	Yes
getROWID()	oracle.sql.ROWID	oracle.sql.ROWID	Yes
getShort()	short	short	No
getString()	String	String	No
getSTRUCT()	oracle.sql.STRUCT	oracle.sql.STRUCT.	Yes
getTime()	java.sql.Time	java.sql.Time	No
getTimestamp()	java.sql.Timestamp	java.sql.Timestamp	No
getUnicodeStream()	java.io.InputStream	java.io.InputStream	No

Special Notes about getXXX() Methods

This section provides additional details about some `getXXX()` methods.

getBigDecimal() Note

JDBC 2.0 simplified method signatures for the `getBigDecimal()` method. The previous input signatures were:

```
(int columnIndex, int scale) or (String columnName, int scale)
```

The simplified input signature is:

```
(int columnIndex) or (String columnName)
```

The `scale` parameter, used to specify the number of digits to the right of the decimal, is no longer necessary. The Oracle JDBC drivers retrieve numeric values with full precision.

getBoolean() Note

Because there is no `BOOLEAN` database type, when you use `getBoolean()` a datatype conversion always occurs. The `getBoolean()` method is supported only for numeric columns (`BIT`, `TINYINT`, `SMALLINT`, `INTEGER`, `BIGINT`, `REAL`, `FLOAT`, `DOUBLE`, `DECIMAL`, `NUMERIC`, `CHAR`, `VARCHAR`, or `LONGVARCHAR`). When applied to these columns, `getBoolean()` interprets any zero (0) value as `false`, and any other value as `true`. When applied to any other sort of column, `getBoolean()` raises the exception `java.lang.NumberFormatException`.

Datatypes For Returned Objects from getObject and getXXX

As described in "Standard getObject() Method" on page 11-3, the return type of `getObject()` is `java.lang.Object`. The returned value is an instance of a subclass of `java.lang.Object`. Similarly, the return type of `getOracleObject()` is `oracle.sql.Datum`, and the class of the returned value is a subclass of `oracle.sql.Datum`. You normally cast the returned object to the appropriate class to use particular methods and functionality of that class.

In addition, you have the option of using a specific `getXXX()` method instead of the generic `getObject()` or `getOracleObject()` methods. The `getXXX()` methods enable you to avoid casting, because the return type of `getXXX()` corresponds to the type of object returned. For example, the return type of `getCLOB()` is `oracle.sql.CLOB`, as opposed to `java.lang.Object`.

Example: Casting Return Values

This example assumes that you have fetched data of type `NUMBER` as column 1 of a result set. Because you want to manipulate the `NUMBER` data without losing precision, cast your result set to an `OracleResultSet`, and use `getOracleObject()` to return the `NUMBER` data in `oracle.sql.*` format. If you do not cast your result set, you have to use `getObject()`, which returns your numeric data into a Java `Float` and loses some of the precision of your SQL data.

The `getOracleObject()` method returns an `oracle.sql.NUMBER` object into an `oracle.sql.Datum` return variable unless you cast the output. Cast the `getOracleObject()` output to `oracle.sql.NUMBER` if you want to use a `NUMBER` return variable and any of the special functionality of that class.

```
NUMBER x = (NUMBER)ors.getOracleObject(1);
```

Alternatively, you can return the object into a generic `oracle.sql.Datum` return variable and cast it later when you use `NUMBER`-specific methods.

```
Datum rawdatum = ors.getOracleObject(1);
...
CharacterSet cs = ((NUMBER) rawdatum).FIXME();
```

This uses the `FIXME()` method of `oracle.sql.NUMBER`. The `FIXME()` method is not defined on `oracle.sql.Datum` and would not be reachable without the cast.

The setObject() and setOracleObject() Methods

Just as there is a standard `getObject()` and Oracle-specific `getOracleObject()` in result sets and callable statements, there are also standard `setObject()` and Oracle-specific `setOracleObject()` methods in `OraclePreparedStatement` and `OracleCallableStatement`. The `setOracleObject()` methods take `oracle.sql.*` input parameters.

To bind standard Java types to a prepared statement or callable statement, use the `setObject()` method, which takes a `java.lang.Object` as input. The `setObject()` method does support a few of the `oracle.sql.*` types—it has been implemented so that you can also input instances of the `oracle.sql.*` classes that correspond to JDBC 2.0-compliant Oracle extensions: `BLOB`, `CLOB`, `BFILE`, `STRUCT`, `REF`, and `ARRAY`.

To bind `oracle.sql.*` types to a prepared statement or callable statement, use the `setOracleObject()` method, which takes a subclass of `oracle.sql.Datum` as input. To use `setOracleObject()`, you must cast your prepared statement or callable statement to `OraclePreparedStatement` or `OracleCallableStatement`.

Example: Using setObject() and setOracleObject()

For a prepared statement, the `setOracleObject()` method binds the `oracle.sql.CHAR` data represented by the `charVal` variable to the prepared statement. To bind the `oracle.sql.*` data, the prepared statement must be cast to an `OraclePreparedStatement`. Similarly, the `setObject()` method binds the Java `String` data represented by the variable `strVal`.

```
PreparedStatement ps= conn.prepareStatement("text_of_prepared_statement");
((OraclePreparedStatement)ps).setOracleObject(1,charVal);
ps.setObject(2,strVal);
```

Other setXXX() Methods

As with `getXXX()` methods, there are several specific `setXXX()` methods. Standard `setXXX()` methods are provided for binding standard Java types, and Oracle-specific `setXXX()` methods are provided for binding Oracle-specific types.

Similarly, there are two forms of the `setNull()` method:

- `void setNull(int parameterIndex, int sqlType)`

  This is specified in the standard `java.sql.PreparedStatement` interface. This signature takes a parameter index and a SQL typecode defined by the `java.sql.Types` or `oracle.jdbc.OracleTypes` class. Use this signature to set an object other than a `REF`, `ARRAY`, or `STRUCT` to `NULL`.

- `void setNull(int parameterIndex, int sqlType, String sql_type_name)`

  With JDBC 2.0, this signature is also specified in the standard `java.sql.PreparedStatement` interface. This method takes a SQL type name in addition to a parameter index and a SQL type code. Use this method when the SQL typecode is `java.sql.Types.REF`, `ARRAY`, or `STRUCT`. (If the typecode is other than `REF`, `ARRAY`, or `STRUCT`, then the given SQL type name is ignored.)

Similarly, the `registerOutParameter()` method has a signature for use with `REF`, `ARRAY`, or `STRUCT` data:

```
void registerOutParameter
            (int parameterIndex, int sqlType, String sql_type_name)
```

For binding Oracle-specific types, using the appropriate specific `setXXX()` methods instead of methods for binding standard Java types may offer some performance advantage.

Input Parameter Types of setXXX() Methods

Table 11–3 summarizes the input types for all the `setXXX()` methods and notes which are Oracle extensions under JDK 1.2.x. To use methods that are Oracle extensions, you must cast your statement to an `OraclePreparedStatement` or `OracleCallableStatement`.

For information on all supported type mappings between SQL and Java, see Table 24–1, " Valid SQL Datatype-Java Class Mappings" on page 24-1.

Table 11–3 Summary of setXXX() Input Parameter Types

Method	Input Parameter Type	Oracle Ext for JDK 1.2.x?
`setArray()`	`java.sql.Array`	No
`setARRAY()`	`oracle.sql.ARRAY`	Yes
`setAsciiStream()` (see Notes section)	`java.io.InputStream`	No
`setBfile()`	`oracle.sql.BFILE`	Yes
`setBFILE()`	`oracle.sql.BFILE`	Yes
`setBigDecimal()`	`BigDecimal`	No
`setBinaryStream()` (see Notes section)	`java.io.InputStream`	No
`setBlob()`	`java.sql.Blob`	No
`setBLOB()`	`oracle.sql.BLOB`	Yes
`setBoolean()`	`boolean`	No
`setByte()`	`byte`	No
`setBytes()`	`byte[]`	No
`setCHAR()` (also see `setFixedCHAR()` method)	`oracle.sql.CHAR`	Yes
`setCharacterStream()` (see Notes section)	`java.io.Reader`	No
`setClob()`	`java.sql.Clob`	No
`setCLOB()`	`oracle.sql.CLOB`	Yes
`setDate()` (see Notes section)	`java.sql.Date`	No
`setDATE()`	`oracle.sql.DATE`	Yes
`setDouble()`	`double`	No
`setFixedCHAR()` (see `setFixedCHAR()` section)	`java.lang.String`	Yes

Table 11–3 (Cont.) Summary of setXXX() Input Parameter Types

Method	Input Parameter Type	Oracle Ext for JDK 1.2.x?
`setFloat()`	`float`	No
`setInt()`	`int`	No
`setLong()`	`long`	No
`setNUMBER()`	`oracle.sql.NUMBER`	Yes
`setRAW()`	`oracle.sql.RAW`	Yes
`setRef()`	`java.sql.Ref`	No
`setREF()`	`oracle.sql.REF`	Yes
`setROWID()`	`oracle.sql.ROWID`	Yes
`setShort()`	`short`	No
`setString()`	`String`	No
`setSTRUCT()`	`oracle.sql.STRUCT`	Yes
`setTime()` (see note below)	`java.sql.Time`	No
`setTimestamp()` (see note below)	`java.sql.Timestamp`	No
`setUnicodeStream()` (see note below)	`java.io.InputStream`	No

Setter Method Size Limitations

Table 11–4 lists size limitations for the `setBytes()` and `setString()` methods for SQL binds. (These limitations do not apply to PL/SQL binds.) For information about how to work around these limits using the stream API, see "Using Streams to Avoid Limits on setBytes() and setString()" on page 4-23.

Table 11–4 Size Limitations for setBytes() and setString() Methods

Method Name	Size Limit
setBytes()	2000 bytes
setString()	4000 bytes

Setter Methods That Take Additional Input

The following `setXXX()` methods take an additional input parameter other than the parameter index and the data item itself:

- `setAsciiStream(int paramIndex, InputStream istream, int length)`

  Takes the length of the stream, in bytes.

- `setBinaryStream(int paramIndex, InputStream istream, int length)`

  Takes the length of the stream, in bytes.

- `setCharacterStream(int paramIndex, Reader reader, int length)`

  Takes the length of the stream, in characters.

- `setUnicodeStream(int paramIndex, InputStream istream, int length)`

  Takes the length of the stream, in bytes.

The particular usefulness of the `setCharacterStream()` method is that when a very large `Unicode` value is input to a `LONGVARCHAR` parameter, it can be more practical to send it through a `java.io.Reader` object. JDBC will read the data from the stream as needed, until it reaches the end-of-file mark. The JDBC driver will do any necessary conversion from `Unicode` to the database character format.

Important: The preceding stream methods can also be used for LOBs. See "Reading and Writing BLOB and CLOB Data" on page 14-4 for more information.

- `setDate(int paramIndex, Date x, Calendar cal)`
- `setTime(int paramIndex, Time x, Calendar cal)`
- `setTimestamp(int paramIndex, Timestamp x, Calendar cal)`

Method setFixedCHAR() for Binding CHAR Data into WHERE Clauses

`CHAR` data in the database is padded to the column width. This leads to a limitation in using the `setCHAR()` method to bind character data into the `WHERE` clause of a `SELECT` statement—the character data in the `WHERE` clause must also be padded to the column width to produce a match in the `SELECT` statement. This is especially troublesome if you do not know the column width.

To remedy this, Oracle has added the `setFixedCHAR()` method to the `OraclePreparedStatement` class. This method executes a non-padded comparison.

Note:

- Remember to cast your prepared statement object to `OraclePreparedStatement` to use the `setFixedCHAR()` method.
- There is no need to use `setFixedCHAR()` for an `INSERT` statement. The database always automatically pads the data to the column width as it inserts it.

Example The following example demonstrates the difference between the `setCHAR()` and `setFixedCHAR()` methods.

```
/* Schema is :
 create table my_table (col1 char(10));
 insert into my_table values ('JDBC');
*/
 PreparedStatement pstmt = conn.prepareStatement
                    ("select count(*) from my_table where col1 = ?");

 pstmt.setString (1, "JDBC");  // Set the Bind Value
 runQuery (pstmt);             // This will print " No of rows are 0"

 CHAR ch = new CHAR("JDBC      ", null);
 ((OraclePreparedStatement)pstmt).setCHAR(1, ch); // Pad it to 10 bytes
 runQuery (pstmt);             // This will print "No of rows are 1"

 ((OraclePreparedStatement)pstmt).setFixedCHAR(1, "JDBC");
  runQuery (pstmt);            // This will print "No of rows are 1"

 void runQuery (PreparedStatement ps)
 {
   // Run the Query
   ResultSet rs = pstmt.executeQuery ();

   while (rs.next())
     System.out.println("No of rows are " + rs.getInt(1));

   rs.close();
   rs = null;
 }
```

Using Result Set Meta Data Extensions

The `oracle.jdbc.OracleResultSetMetaData` interface is JDBC 2.0-compliant but does not implement the `getSchemaName()` and `getTableName()` methods because underlying protocol does not make this feasible. Oracle does implement many methods to retrieve information about an Oracle result set, however.

Key methods include the following:

- `int getColumnCount()`: Returns the number of columns in an Oracle result set.
- `String getColumnName(int column)`: Returns the name of a specified column in an Oracle result set.
- `int getColumnType(int column)`: Returns the SQL type of a specified column in an Oracle result set. If the column stores an Oracle object or collection, then this method returns `OracleTypes.STRUCT` or `OracleTypes.ARRAY` respectively.
- `String getColumnTypeName(int column)`: Returns the SQL type name for a specified column of type `REF`, `STRUCT`, or `ARRAY`. If the column stores an array or collection, then this method returns its SQL type name. If the column stores `REF` data, then this method returns the SQL type name of the objects to which the object reference points.

The following example uses several of the methods in the `OracleResultSetMetadata` interface to retrieve the number of columns from the `EMP` table, and each column's numerical type and SQL type name.

```
DatabaseMetaData dbmd = conn.getMetaData();
ResultSet rset = dbmd.getTables("", "SCOTT", "EMP", null);

 while (rset.next())
 {
   OracleResultSetMetaData orsmd = ((OracleResultSet)rset).getMetaData();
   int numColumns = orsmd.getColumnCount();
   System.out.println("Num of columns = " + numColumns);

   for (int i=0; i<numColumns; i++)
   {
     System.out.print ("Column Name=" + orsmd.getColumnName (i+1));
     System.out.print (" Type=" + orsmd.getColumnType (i + 1) );
     System.out.println (" Type Name=" + orsmd.getColumnTypeName (i + 1));
  }
}
```

The program returns the following output:

```
Num of columns = 5
Column Name=TABLE_CAT Type=12 Type Name=VARCHAR2
Column Name=TABLE_SCHEM Type=12 Type Name=VARCHAR2
Column Name=TABLE_NAME Type=12 Type Name=VARCHAR2
Column Name=TABLE_TYPE Type=12 Type Name=VARCHAR2
Column Name=TABLE_REMARKS Type=12 Type Name=VARCHAR2
```

12

Globalization Support

Oracle's JDBC drivers provide Globalization Support (formerly NLS). Globalization Support allows you retrieve data or insert data into a database in any character set that Oracle supports. If the clients and the server use different character sets, then the driver provides the support to perform the conversions between the database character set and the client character set.

This chapter contains the following sections:

For more information on Globalization Support, Globalization Support environment variables, and the character sets that Oracle supports, see "Oracle Character Datatypes Support" on page 10-19 and the *Oracle Database Globalization Support Guide*. See the *Oracle Database Reference* for more information on the database character set and how it is created.

Notes:

- As of 10*g* Release 1 (10.1), the `NLS_LANG` variable is no longer part of the globalization mechanism; setting it has no effect.
- The JDBC Server-side Internal driver provides complete globalization support, and does not require any globalization extension files. You can skip this chapter if you only use the Server-side Internal driver.

Providing Globalization Support

The basic JAR files (`classes12.jar` and `ojdbc14.jar`) contain all the necessary classes to provide complete globalization support for:

- Oracle character sets for `CHAR`, `VARCHAR`. `LONGVARCHAR`, or `CLOB` data that is not being retrieved or inserted as a data member of an Oracle 8 Object or Collection type.
- `CHAR` or `VARCHAR` data members of Object and Collection for the character sets`US7ASCII`, `WE8DEC`, `WE8ISO8859P1` and `UTF8`.

To use any other character sets in `CHAR` or `VARCHAR` data members of Objects or Collections, you must include `orai18n.jar` in your application's `CLASSPATH`.

> **Note:** Previous releases depended on the file `nls_charset12.zip`; this file is now obsolete.

The file `orai18n.jar` is large because it supports a large number of character sets. You can include only the character set classes you use in your application. To do so, unpack `orai18n.jar`, then put only the necessary files in your `CLASSPATH`.

The character set extension class files are named in the following format:

Name	Datatype
lx20*OracleCharacterSetId*.glb	Character set
lx1*OracleTerritoryId*.glb	Territory
lx3*OracleLinguisticSortId*.glb	Collation sequence
lx4*OracleMappingId*.glb	Mapping

where *`Oracle...Id`* is the hexadecimal representation of the Oracle character set, territory, collation sequence, or mapping ID that corresponds to a character set name. These IDs can be found in the *Oracle Globalization Development Kit Java API Reference*.

You can also include internationalized JDBC error message files selectively. The message files are included in `classes*.*` under the name `oracle/jdbc/driver/Messages_*.properties`.

NCHAR, NVARCHAR2, NCLOB and the defaultNChar Property

By default, `oracle.jdbc.OraclePreparedStatement` treats all columns as `CHAR`. To insert Java strings into `NCHAR`, `NVARCHAR2`, and `NCLOB` columns, developers had to invoke `setFormOfUse()` on each national-language column. At this release, if you set the system property `oracle.jdbc.defaultNChar` to true, JDBC treats all character columns as being national-language. The default value for `defaultNChar` is false.

To set defaultNChar, you specify a command line like:

```
java -Doracle.jdbc.defaultNChar=true myApplication
```

If you prefer, your application can specify `defaultNChar` as a connection property.

After this property is set, your application can access NCHAR, NVARCHAR2, or NCLOB data without invoking setFormOfUse(). For example:

```
PreparedStatement pstmt =
conn.prepareStatement("insert into TEST values(?,?,?)");
pstmt.setInt(1, 1); // NUMBER column
pstmt.setString(2, myUnicodeString1); // NVARCHAR2 column
pstmt.setString(3, myUnicodeString2); // NCHAR column
pstmt.execute();
```

However, if you set defaultNChar to true and then access CHAR columns, the database will implicitly convert all CHAR data into NCHAR. This conversion has a substantial performance impact. To avoid this, call setFormOfUse(4,OraclePreparedStatement.FORM_CHAR) for each CHAR referred to in the statement. For example:

```
PreparedStatement pstmt =
conn.prepareStatement("insert into TEST values(?,?,?)");
pstmt.setInt(1, 1); // NUMBER column
pstmt.setString(2, myUnicodeString1); // NVARCHAR2 column
pstmt.setString(3, myUnicodeString2); // NCHAR column
pstmt.setFormOfUse(4, OraclePreparedStatement.FORM_CHAR);
pstmt.setString(4, myString); // CHAR column
pstmt.execute();
```

JDBC Methods Dependent On Conversion

Here are a few examples of commonly used Java methods for JDBC that rely heavily on character set conversion:

- The java.sql.ResultSet methods getString() and getUnicodeStream() return values from the database as Java strings and as a stream of Unicode characters, respectively.
- The oracle.sql.CLOB method getCharacterStream() returns the contents of a CLOB as a Unicode stream.
- The oracle.sql.CHAR methods getString(), toString(), and getStringWithReplacement() convert the following data to strings:
  - getString(): This converts the sequence of characters represented by the CHAR object to a string and returns a Java String object.
  - toString(): This is identical to getString(), but if the character set is not recognized, then toString() returns a hexadecimal representation of the CHAR data.
  - getStringWithReplacement(): This is identical to getString(), except characters that have no Unicode representation in the character set of this CHAR object are replaced by a default replacement character.

13

Working with Oracle Object Types

This chapter describes JDBC support for user-defined object types. It discusses functionality of the generic, weakly typed `oracle.sql.STRUCT` class, as well as how to map to custom Java classes that implement either the JDBC standard `SQLData` interface or the Oracle `ORAData` interface.

The following topics are covered:

- Mapping Oracle Objects
- Using the Default STRUCT Class for Oracle Objects
- Creating and Using Custom Object Classes for Oracle Objects
- Object-Type Inheritance
- Using JPublisher to Create Custom Object Classes
- Describing an Object Type

> **Note:** For general information about Oracle object features and functionality, see the *Oracle Database Application Developer's Guide - Object-Relational Features*.

Mapping Oracle Objects

Oracle object types provide support for composite data structures in the database. For example, you can define a type `Person` that has attributes such as name (type `CHAR`), phone number (type `CHAR`), and employee number (type `NUMBER`).

Oracle provides tight integration between its Oracle object features and its JDBC functionality. You can use a standard, generic JDBC type to map to Oracle objects, or you can customize the mapping by creating custom Java type definition classes. In this book, Java classes that you create to map to Oracle objects will be referred to as *custom Java classes* or, more specifically, *custom object classes*. This is as opposed to *custom references classes* to map to object references, and *custom collection classes* to map to Oracle collections. Custom object classes can implement either a standard JDBC interface or an Oracle extension interface to read and write data.

JDBC materializes Oracle objects as instances of particular Java classes. Two main steps in using JDBC to access Oracle objects are: 1) creating the Java classes for the Oracle objects, and 2) populating these classes. You have two options:

- Let JDBC materialize the object as a `STRUCT`. This is described in "Using the Default STRUCT Class for Oracle Objects" on page 13-2.

or:

- Explicitly specify the mappings between Oracle objects and Java classes. This includes customizing your Java classes for object data. The driver then must be able to populate instances of the custom object classes that you specify. This imposes a set of constraints on the Java classes. To satisfy these constraints, you can define your classes to implement either the JDBC standard `java.sql.SQLData` interface or the Oracle extension `oracle.sql.ORAData` interface. This is described in "Creating and Using Custom Object Classes for Oracle Objects" on page 13-7.

  You can use the Oracle JPublisher utility to generate custom Java classes.

  Note: When you use the `SQLData` interface, you must use a Java type map to specify your SQL-Java mapping, unless weakly typed `java.sql.Struct` objects will suffice. See "Understanding Type Maps for SQLData Implementations" on page 13-8.

Using the Default STRUCT Class for Oracle Objects

If you choose not to supply a custom Java class for your SQL-Java mapping for an Oracle object, then Oracle JDBC will materialize the object as an instance of the `oracle.sql.STRUCT` class.

You would typically want to use `STRUCT` objects, instead of custom Java objects, in situations where you are manipulating SQL data. For example, your Java application might be a tool to manipulate arbitrary object data within the database, as opposed to being an end-user application. You can select data from the database into `STRUCT` objects and create `STRUCT` objects for inserting data into the database. `STRUCT` objects completely preserve data, because they maintain the data in SQL format. Using `STRUCT` objects is more efficient and more precise in these situations where you don't need the information in a convenient form.

STRUCT Class Functionality

This section discusses standard versus Oracle-specific features of the `oracle.sql.STRUCT` class, introduces `STRUCT` descriptors, and lists methods of the `STRUCT` class to give an overview of its functionality.

Standard java.sql.Struct Methods

If your code must comply with standard JDBC 2.0, then use a `java.sql.Struct` instance and use the following standard methods:

- `getAttributes(map)`: Retrieves the values of the attributes, using entries in the specified type map to determine the Java classes to use in materializing any attribute that is a structured object type. The Java types for other attribute values would be the same as for a `getObject()` call on data of the underlying SQL type (the default JDBC types).
- `getAttributes()`: This is the same as the preceding `getAttributes(map)` method, except it uses the default type map for the connection.
- `getSQLTypeName()`: Returns a Java `String` that represents the fully qualified name (*`schema.sql_type_name`*) of the Oracle object type that this `Struct` represents (such as `SCOTT.EMPLOYEE`).

Oracle oracle.sql.STRUCT Class Methods

If you want to take advantage of the extended functionality offered by Oracle-defined methods, then use an `oracle.sql.STRUCT` instance.

The `oracle.sql.STRUCT` class implements the `java.sql.Struct` interface and provides extended functionality beyond the JDBC 2.0 standard.

The `STRUCT` class includes the following methods in addition to standard `Struct` functionality:

- `getOracleAttributes()`: Retrieves the values of the values array as `oracle.sql.*` objects.
- `getDescriptor()`: Returns the `StructDescriptor` object for the SQL type that corresponds to this `STRUCT` object.
- `getJavaSQLConnection()`: Returns the current connection instance (`java.sql.Connection`).
- `toJdbc()`: Consults the default type map of the connection, to determine what class to map to, and then uses `toClass()`.
- `toJdbc(map)`: Consults the specified type map to determine what class to map to, and then uses `toClass()`.

STRUCT Descriptors

Creating and using a `STRUCT` object requires a descriptor—an instance of the `oracle.sql.StructDescriptor` class—to exist for the SQL type (such as `EMPLOYEE`) that will correspond to the `STRUCT` object. You need only one `StructDescriptor` object for any number of `STRUCT` objects that correspond to the same SQL type.

`STRUCT` descriptors are further discussed in "Creating STRUCT Objects and Descriptors" on page 13-3.

Creating STRUCT Objects and Descriptors

This section describes how to create `STRUCT` objects and descriptors and lists useful methods of the `StructDescriptor` class.

Steps in Creating StructDescriptor and STRUCT Objects

This section describes how to construct an `oracle.sql.STRUCT` object for a given Oracle object type. To create a `STRUCT` object, you must:

1. Create a `StructDescriptor` object (if one does not already exist) for the given Oracle object type.
2. Use the `StructDescriptor` to construct the `STRUCT` object.

A `StructDescriptor` is an instance of the `oracle.sql.StructDescriptor` class and describes a type of Oracle object (SQL structured object). Only one `StructDescriptor` is necessary for each Oracle object type. The driver caches `StructDescriptor` objects to avoid recreating them if the type has already been encountered.

Before you can construct a `STRUCT` object, a `StructDescriptor` must first exist for the given Oracle object type. If a `StructDescriptor` object does not exist, you can create one by calling the static `StructDescriptor.createDescriptor()` method. This method requires you to pass in the SQL type name of the Oracle object type and a connection object:

```
StructDescriptor structdesc = StructDescriptor.createDescriptor
                                          (sql_type_name, connection);
```

Where *`sql_type_name`* is a Java string containing the name of the Oracle object type (such as `EMPLOYEE`) and `connection` is your connection object.

Once you have your `StructDescriptor` object for the Oracle object type, you can construct the `STRUCT` object. To do this, pass in the `StructDescriptor`, your connection object, and an array of Java objects containing the attributes you want the `STRUCT` to contain.

```
STRUCT struct = new STRUCT(structdesc, connection, attributes);
```

Where `structdesc` is the `StructDescriptor` created previously, `connection` is your connection object, and `attributes` is an array of type `java.lang.Object[]`.

Using StructDescriptor Methods

A `StructDescriptor` can be thought of as a "type object". This means that it contains information about the object type, including the typecode, the type name, and how to convert to and from the given type. Remember, there should be only one `StructDescriptor` object for any one Oracle object type. You can then use that descriptor to create as many `STRUCT` objects as you need for that type.

The `StructDescriptor` class includes the following methods:

- `getName()`: Returns the fully qualified SQL type name of the Oracle object (that is, in *`schema.sql_type_name`* format, such as `CORPORATE.EMPLOYEE`).
- `getLength()`: Returns the number of fields in the object type.
- `getMetaData()`: Returns the meta data regarding this type (like the `getMetaData()` method of a result set object). The returned `ResultSetMetaData` object contains the attribute name, attribute typecode, and attribute type precision information. The "column" index in the `ResultSetMetaData` object maps to the position of the attribute in the `STRUCT`, with the first attribute being at index 1.

  The `getMetaData()` method is further discussed in "Functionality for Getting Object Meta Data" on page 13-35.

Serializable STRUCT Descriptors

As "Steps in Creating StructDescriptor and STRUCT Objects" on page 13-4 explains, when you create a `STRUCT` object, you first must create a `StructDescriptor` object. Do this by calling the `StructDescriptor.createDescriptor()` method. The `oracle.sql.StructDescriptor` class is serializable, meaning that you can write the complete state of a `StructDescriptor` object to an output stream for later use. Recreate the `StructDescriptor` object by reading its serialized state from an input stream. This is referred to as *deserializing*. With the `StructDescriptor` object serialized, you do not need to call the `StructDescriptor.createDescriptor()` method—you simply deserialize the `StructDescriptor` object.

It is advisable to serialize a `StructDescriptor` object when the object type is complex but not changed often.

If you create a `StructDescriptor` object through deserialization, you must supply the appropriate database connection instance for the `StructDescriptor` object, using the `setConnection()` method.

The following code provides the connection instance for a `StructDescriptor` object:

```
public void setConnection (Connection conn) throws SQLException
```

> **Note:** The JDBC driver does not verify that the connection object from the `setConnection()` method connects to the same database from which the type descriptor was initially derived.

Retrieving STRUCT Objects and Attributes

This section discusses how to retrieve and manipulate Oracle objects and their attributes, using either Oracle-specific features or JDBC 2.0 standard features.

> **Note:** The JDBC driver seamlessly handles embedded objects (`STRUCT` objects that are attributes of `STRUCT` objects) in the same way that it normally handles objects. When the JDBC driver retrieves an attribute that is an object, it follows the same rules of conversion, using the type map if it is available, or using default mapping if it is not.

Retrieving an Oracle Object as an oracle.sql.STRUCT Object

You can retrieve an Oracle object directly into an `oracle.sql.STRUCT` instance. In the following example, `getObject()` is used to get a `NUMBER` object from column 1 (`col1`) of the table `struct_table`. Because `getObject()` returns an `Object` type, the return is cast to an `oracle.sql.STRUCT`. This example assumes that the `Statement` object `stmt` has already been created.

```
String cmd;
cmd = "CREATE TYPE type_struct AS object (field1 NUMBER,field2 DATE)";
stmt.execute(cmd);

cmd = "CREATE TABLE struct_table (col1 type_struct)";
stmt.execute(cmd);

cmd = "INSERT INTO struct_table VALUES (type_struct(10,'01-apr-01'))";
stmt.execute(cmd);
```

```
cmd = "INSERT INTO struct_table VALUES (type_struct(20,'02-may-02'))";
stmt.execute(cmd);

ResultSet rs= stmt.executeQuery("SELECT * FROM struct_table");
oracle.sql.STRUCT oracleSTRUCT=(oracle.sql.STRUCT)rs.getObject(1);
```

Another way to return the object as a `STRUCT` object is to cast the result set to an `OracleResultSet` object and use the Oracle extension `getSTRUCT()` method:

```
oracle.sql.STRUCT oracleSTRUCT=((OracleResultSet)rs).getSTRUCT(1);
```

Retrieving an Oracle Object as a java.sql.Struct Object

Alternatively, referring back to the previous example, you can use standard JDBC functionality such as `getObject()` to retrieve an Oracle object from the database as an instance of `java.sql.Struct`. Because `getObject()` returns a `java.lang.Object`, you must cast the output of the method to a `Struct`. For example:

```
ResultSet rs= stmt.executeQuery("SELECT * FROM struct_table");
java.sql.Struct jdbcStruct = (java.sql.Struct)rs.getObject(1);
```

Retrieving Attributes as oracle.sql Types

If you want to retrieve Oracle object attributes from a `STRUCT` or `Struct` instance as `oracle.sql` types, use the `getOracleAttributes()` method of the `oracle.sql.STRUCT` class (for a `Struct` instance, you will have to cast to a `STRUCT` instance):

Referring back to the previous examples:

```
oracle.sql.Datum[] attrs = oracleSTRUCT.getOracleAttributes();
```

or:

```
oracle.sql.Datum[] attrs =
        ((oracle.sql.STRUCT)jdbcStruct).getOracleAttributes();
```

Retrieving Attributes as Standard Java Types

If you want to retrieve Oracle object attributes as standard Java types from a `STRUCT` or `Struct` instance, use the standard `getAttributes()` method:

```
Object[] attrs = jdbcStruct.getAttributes();
```

Note: The Oracle JDBC drivers cache array and structure descriptors. This provides enormous performance benefits; however, it means that if you change the underlying type definition of a structure type in the database, the cached descriptor for that structure type will become stale and your application will receive a `SQLException`.

Binding STRUCT Objects into Statements

To bind an `oracle.sql.STRUCT` object to a prepared statement or callable statement, you can either use the standard `setObject()` method (specifying the typecode), or

cast the statement object to an Oracle statement object and use the Oracle extension `setOracleObject()` method. For example:

```
PreparedStatement ps= conn.prepareStatement("text_of_prepared_statement");
STRUCT mySTRUCT = new STRUCT (...);
ps.setObject(1, mySTRUCT, Types.STRUCT);
```

or:

```
PreparedStatement ps= conn.prepareStatement("text_of_prepared_statement");
STRUCT mySTRUCT = new STRUCT (...);
((OraclePreparedStatement)ps).setOracleObject(1, mySTRUCT);
```

STRUCT Automatic Attribute Buffering

The Oracle JDBC driver furnishes public methods to enable and disable buffering of `STRUCT` attributes. (See "ARRAY Automatic Element Buffering" on page 16-6 for a discussion of how to buffer `ARRAY` elements.)

The following methods are included with the `oracle.sql.STRUCT` class:

- `public void setAutoBuffering(boolean enable)`
- `public boolean getAutoBuffering()`

The `setAutoBuffering(boolean)` method enables or disables auto-buffering. The `getAutoBuffering()` method returns the current auto-buffering mode. By default, auto-buffering is disabled.

It is advisable to enable auto-buffering in a JDBC application when the `STRUCT` attributes will be accessed more than once by the `getAttributes()` and `getArray()` methods (presuming the `ARRAY` data is able to fit into the JVM memory without overflow).

Important: Buffering the converted attributes may cause the JDBC application to consume a significant amount of memory.

When you enable auto-buffering, the `oracle.sql.STRUCT` object keeps a local copy of all the converted attributes. This data is retained so that a second access of this information does not require going through the data format conversion process.

Creating and Using Custom Object Classes for Oracle Objects

If you want to create custom object classes for your Oracle objects, then you must define entries in the type map that specify the custom object classes that the drivers will instantiate for the corresponding Oracle objects.

You must also provide a way to create and populate instances of the custom object class from the Oracle object and its attribute data. The driver must be able to read from a custom object class and write to it. In addition, the custom object class can provide `getXXX()` and `setXXX()` methods corresponding to the Oracle object's attributes, although this is not necessary. To create and populate the custom classes and provide these read/write capabilities, you can choose between these two interfaces:

- the JDBC standard `SQLData` interface
- the `ORAData` and `ORADataFactory` interfaces provided by Oracle

The custom object class you create must implement one of these interfaces. The `ORAData` interface can also be used to implement the custom reference class

corresponding to the custom object class. If you are using the SQLData interface, however, you can only use weak reference types in Java (java.sql.Ref or oracle.sql.REF). The SQLData interface is for mapping SQL objects only.

As an example, assume you have an Oracle object type, EMPLOYEE, in the database that consists of two attributes: Name (which is type CHAR) and EmpNum (employee number, which is type NUMBER). You use the type map to specify that the EMPLOYEE object should map to a custom object class that you call JEmployee. You can implement either the SQLData or ORAData interface in the JEmployee class.

You can create custom object classes yourself, but the most convenient way to create them is to employ the Oracle JPublisher utility to create them for you. JPublisher supports the standard SQLData interface as well as the Oracle-specific ORAData interface, and is able to generate classes that implement either one. See "Using JPublisher to Create Custom Object Classes" on page 13-32 for more information.

Note: If you need to create a custom object class in order to have object-type inheritance, then see "Object-Type Inheritance" on page 13-21.

The following section compares ORAData and SQLData functionality.

Relative Advantages of ORAData versus SQLData

In deciding which of these two interface implementations to use, consider the following:

Advantages of ORAData:

- It does not require an entry in the type map for the Oracle object.
- It has awareness of Oracle extensions.
- You can construct a ORAData from an oracle.sql.STRUCT. This is more efficient because it avoids unnecessary conversions to native Java types.
- You can obtain the corresponding Datum object (which is in oracle.sql format) from the ORAData object, using the toDatum() method.
- It provides better performance: ORAData works directly with Datum types, which is the internal format used by the driver to hold Oracle objects.

Advantages of SQLData:

- It is a JDBC standard, making your code more portable.

The SQLData interface is for mapping SQL objects only. The ORAData interface is more flexible, enabling you to map SQL objects as well as any other SQL type for which you want to customize processing. You can create a ORAData object from any datatype found in an Oracle database. This could be useful, for example, for serializing RAW data in Java.

Understanding Type Maps for SQLData Implementations

If you use the SQLData interface in a custom object class, then you must create type map entries that specify the custom object class to use in mapping the Oracle object type (SQL object type) to Java. You can either use the default type map of the connection object, or a type map that you specify when you retrieve the data from the result set. The ResultSet interface getObject() method has a signature that lets you specify a type map:

```
rs.getObject(int columnIndex);
```

or:

```
rs.getObject(int columnIndex, Map map);
```

For a description of how to create these custom object classes with `SQLData`, see "Creating and Using Custom Object Classes for Oracle Objects" on page 13-7.

When using a SQLData implementation, if you do not include a type map entry, then the object will map to the `oracle.sql.STRUCT` class by default. (`ORAData` implementations, by contrast, have their own mapping functionality so that a type map entry is not required. When using a `ORAData` implementation, use the Oracle `getORAData()` method instead of the standard `getObject()` method.)

The type map relates a Java class to the SQL type name of an Oracle object. This one-to-one mapping is stored in a hash table as a keyword-value pair. When you read data from an Oracle object, the JDBC driver considers the type map to determine which Java class to use to materialize the data from the Oracle object type (SQL object type). When you write data to an Oracle object, the JDBC driver gets the SQL type name from the Java class by calling the `getSQLTypeName()` method of the `SQLData` interface. The actual conversion between SQL and Java is performed by the driver.

The attributes of the Java class that corresponds to an Oracle object can use either Java native types or Oracle native types (instances of the `oracle.sql.*` classes) to store attributes.

Creating a Type Map Object and Defining Mappings for a SQLData Implementation

When using a `SQLData` implementation, the JDBC applications programmer is responsible for providing a type map, which must be an instance of a class that implements the standard `java.util.Map` interface.

You have the option of creating your own class to accomplish this, but the standard class `java.util.Hashtable` meets the requirement.

> **Note:** If you are migrating from JDK 1.1.x to JDK 1.2.x, you must ensure that your code uses a class that implements the `Map` interface. If you were using the `java.util.Hashtable` class under 1.1.x, then no change is necessary.

`Hashtable` and other classes used for type maps implement a `put()` method that takes keyword-value pairs as input, where each key is a fully qualified SQL type name and the corresponding value is an instance of a specified Java class.

A type map is associated with a connection instance. The standard `java.sql.Connection` interface and the Oracle-specific `oracle.jdbc.OracleConnection` interface include a `getTypeMap()` method. Both return a `Map` object.

The remainder of this section covers the following topics:

- Adding Entries to an Existing Type Map
- Creating a New Type Map

Adding Entries to an Existing Type Map

When a connection instance is first established, the default type map is empty. You must populate it to use any SQL-Java mapping functionality.

Follow these general steps to add entries to an existing type map.

1. Use the `getTypeMap()` method of your `OracleConnection` object to return the connection's type map object. The `getTypeMap()` method returns a `java.util.Map` object. For example, presuming an `OracleConnection` instance `oraconn`:

   ```
   java.util.Map myMap = oraconn.getTypeMap();
   ```

   Note: If the type map in the `OracleConnection` instance has not been initialized, then the first call to `getTypeMap()` returns an empty map.

2. Use the type map's `put()` method to add map entries. The `put()` method takes two arguments: a SQL type name string and an instance of a specified Java class that you want to map to.

   ```
   myMap.put(sqlTypeName, classObject);
   ```

   The *`sqlTypeName`* is a string that represents the fully qualified name of the SQL type in the database. The *`classObject`* is the Java class object to which you want to map the SQL type. Get the class object with the `Class.forName()` method, as follows:

   ```
   myMap.put(sqlTypeName, Class.forName(className));
   ```

   For example, if you have a `PERSON` SQL datatype defined in the `CORPORATE` database schema, then map it to a `Person` Java class defined as `Person` with this statement:

   ```
   myMap.put("CORPORATE.PERSON", Class.forName("Person"));
   ```

   The map has an entry that maps the `PERSON` SQL datatype in the `CORPORATE` database to the `Person` Java class.

   Note: SQL type names in the type map must be all uppercase, because that is how the Oracle database stores SQL names.

Creating a New Type Map

Follow these general steps to create a new type map. This example uses an instance of `java.util.Hashtable`, which extends `java.util.Dictionary` and, under JDK 1.2.x, also implements `java.util.Map`.

1. Create a new type map object.

   ```
   Hashtable newMap = new Hashtable();
   ```

2. Use the `put()` method of the type map object to add entries to the map. For more information on the `put()` method, see Step 2 under "Adding Entries to an Existing Type Map" on page 13-10. For example, if you have an `EMPLOYEE` SQL type defined in the `CORPORATE` database, then you can map it to an `Employee` class object defined by `Employee.java`, with this statement:

```
newMap.put("CORPORATE.EMPLOYEE", class.forName("Employee"));
```

3. When you finish adding entries to the map, use the `OracleConnection` object's `setTypeMap()` method to overwrite the connection's existing type map. For example:

   ```
   oraconn.setTypeMap(newMap);
   ```

   In this example, `setTypeMap()` overwrites the `oraconn` connection's original map with `newMap`.

   Note: The default type map of a connection instance is used when mapping is required but no map name is specified, such as for a result set `getObject()` call that does not specify the map as input.

Materializing Object Types not Specified in the Type File

If you do not provide a type map with an appropriate entry when using a `getObject()` call, then the JDBC driver will materialize an Oracle object as an instance of the `oracle.sql.STRUCT` class. If the Oracle object type contains embedded objects, and they are not present in the type map, the driver will materialize the embedded objects as instances of `oracle.sql.STRUCT` as well. If the embedded objects are present in the type map, a call to the `getAttributes()` method will return embedded objects as instances of the specified Java classes from the type map.

Understanding the SQLData Interface

One of the choices in making an Oracle object and its attribute data available to Java applications is to create a custom object class that implements the `SQLData` interface. Note that if you use this interface, you must supply a type map that specifies the Oracle object types in the database and the names of the corresponding custom object classes that you will create for them.

The `SQLData` interface defines methods that translate between SQL and Java for Oracle database objects. Standard JDBC provides a `SQLData` interface and companion `SQLInput` and `SQLOutput` interfaces in the `java.sql` package.

If you create a custom object class that implements `SQLData`, then you must provide a `readSQL()` method and a `writeSQL()` method, as specified by the `SQLData` interface.

The JDBC driver calls your `readSQL()` method to read a stream of data values from the database and populate an instance of your custom object class. Typically, the driver would use this method as part of an `OracleResultSet` object `getObject()` call.

Similarly, the JDBC driver calls your `writeSQL()` method to write a sequence of data values from an instance of your custom object class to a stream that can be written to the database. Typically, the driver would use this method as part of an `OraclePreparedStatement` object `setObject()` call.

Understanding the SQLInput and SQLOutput Interfaces

The JDBC driver includes classes that implement the `SQLInput` and `SQLOutput` interfaces. It is not necessary to implement the `SQLOutput` or `SQLInput` objects—the JDBC drivers will do this for you.

The `SQLInput` implementation is an input stream class, an instance of which must be passed in to the `readSQL()` method. `SQLInput` includes a `readXXX()` method for

every possible Java type that attributes of an Oracle object might be converted to, such as `readObject()`, `readInt()`, `readLong()`, `readFloat()`, `readBlob()`, and so on. Each `readXXX()` method converts SQL data to Java data and returns it into an output parameter of the corresponding Java type. For example, `readInt()` returns an integer.

The `SQLOutput` implementation is an output stream class, an instance of which must be passed in to the `writeSQL()` method. `SQLOutput` includes a `writeXXX()` method for each of these Java types. Each `writeXXX()` method converts Java data to SQL data, taking as input a parameter of the relevant Java type. For example, `writeString()` would take as input a string attribute from your Java class.

Implementing readSQL() and writeSQL() Methods

When you create a custom object class that implements `SQLData`, you must implement the `readSQL()` and `writeSQL()` methods, as described here.

You must implement `readSQL()` as follows:

```
public void readSQL(SQLInput stream, String sql_type_name) throws SQLException
```

- The `readSQL()` method takes as input a `SQLInput` stream and a string that indicates the SQL type name of the data (in other words, the name of the Oracle object type, such as `EMPLOYEE`).

  When your Java application calls `getObject()`, the JDBC driver creates a `SQLInput` stream object and populates it with data from the database. The driver can also determine the SQL type name of the data when it reads it from the database. When the driver calls `readSQL()`, it passes in these parameters.

- For each Java datatype that maps to an attribute of the Oracle object, `readSQL()` must call the appropriate `readXXX()` method of the `SQLInput` stream that is passed in.

  For example, if you are reading `EMPLOYEE` objects that have an employee name as a `CHAR` variable and an employee number as a `NUMBER` variable, you must have a `readString()` call and a `readInt()` call in your `readSQL()` method. JDBC calls these methods according to the order in which the attributes appear in the SQL definition of the Oracle object type.

- The `readSQL()` method takes the data that the `readXXX()` methods read and convert, and assigns them to the appropriate fields or elements of a custom object class instance.

You must implement `writeSQL()` as follows:

```
public void writeSQL(SQLOutput stream) throws SQLException
```

- The `writeSQL()` method takes as input a `SQLOutput` stream.

  When your Java application calls `setObject()`, the JDBC driver creates a `SQLOutput` stream object and populates it with data from a custom object class instance. When the driver calls `writeSQL()`, it passes in this stream parameter.

- For each Java datatype that maps to an attribute of the Oracle object, `writeSQL()` must call the appropriate `writeXXX()` method of the `SQLOutput` stream that is passed in.

  For example, if you are writing to `EMPLOYEE` objects that have an employee name as a `CHAR` variable and an employee number as a `NUMBER` variable, then you must have a `writeString()` call and a `writeInt()` call in your `writeSQL()`

method. These methods must be called according to the order in which attributes appear in the SQL definition of the Oracle object type.

- The `writeSQL()` method then writes the data converted by the `writeXXX()` methods to the `SQLOutput` stream so that it can be written to the database once you execute the prepared statement.

Reading and Writing Data with a SQLData Implementation

This section describes how to read data from an Oracle object or write data to an Oracle object if your corresponding Java class implements `SQLData`.

Reading SQLData Objects from a Result Set

This section summarizes the steps to read data from an Oracle object into your Java application when you choose the `SQLData` implementation for your custom object class.

These steps assume you have already defined the Oracle object type, created the corresponding custom object class, updated the type map to define the mapping between the Oracle object and the Java class, and defined a statement object `stmt`.

1. Query the database to read the Oracle object into a JDBC result set.

   ```
   ResultSet rs = stmt.executeQuery("SELECT emp_col FROM personnel");
   ```

   The `PERSONNEL` table contains one column, `EMP_COL`, of SQL type `EMP_OBJECT`. This SQL type is defined in the type map to map to the Java class `Employee`.

2. Use the `getObject()` method of your result set to populate an instance of your custom object class with data from one row of the result set. The `getObject()` method returns the user-defined `SQLData` object because the type map contains an entry for `Employee`.

   ```
   if (rs.next())
      Employee emp = (Employee)rs.getObject(1);
   ```

   Note that if the type map did not have an entry for the object, then `getObject()` would return an `oracle.sql.STRUCT` object. Cast the output to type `STRUCT`, because the `getObject()` method signature returns the generic `java.lang.Object` type.

   ```
   if (rs.next())
      STRUCT empstruct = (STRUCT)rs.getObject(1);
   ```

   The `getObject()` call triggers `readSQL()` and `readXXX()` calls from the `SQLData` interface, as described above.

   Note: If you want to avoid using a type map, then use the `getSTRUCT()` method. This method always returns a `STRUCT` object, even if there is a mapping entry in the type map.

3. If you have `get` methods in your custom object class, then use them to read data from your object attributes. For example, if `EMPLOYEE` has an `EmpName` (employee name) of type `CHAR`, and an `EmpNum` (employee number) of type `NUMBER`, then provide a `getEmpName()` method that returns a Java `String` and a `getEmpNum()` method that returns an integer (`int`). Then invoke them in your Java application, as follows:

```
String empname = emp.getEmpName();
int empnumber = emp.getEmpNum();
```

> **Note:** Alternatively, fetch data by using a callable statement object, which also has a `getObject()` method.

Retrieving SQLData Objects from a Callable Statement OUT Parameter

Suppose you have an `OracleCallableStatement ocs` that calls a PL/SQL function `GETEMPLOYEE()`. The program passes an employee number (`empnumber`) to the function; the function returns the corresponding `Employee` object.

1. Prepare an `OracleCallableStatement` to call the `GETEMPLOYEE()` function.

```
OracleCallableStatement ocs =
  (OracleCallableStatement)conn.prepareCall("{ ? = call GETEMPLOYEE(?) }");
```

1. Declare the `empnumber` as the input parameter to `GETEMPLOYEE()`. Register the `SQLData` object as the `OUT` parameter, with typecode `OracleTypes.STRUCT`. Then, execute the statement.

```
ocs.setInt(2, empnumber);
ocs.registerOutParameter(1, OracleTypes.STRUCT, "EMP_OBJECT");
ocs.execute();
```

2. Use the `getObject()` method to retrieve the employee object. The following code assumes that there is a type map entry to map the Oracle object to Java type `Employee`:

```
Employee emp = (Employee)ocs.getObject(1);
```

   If there is no type map entry, then `getObject()` would return an `oracle.sql.STRUCT` object. Cast the output to type `STRUCT`, because the `getObject()` method signature returns the generic `java.lang.Object` type:

```
STRUCT emp = (STRUCT)ocs.getObject(1);
```

Passing SQLData Objects to a Callable Statement as an IN Parameter

Suppose you have a PL/SQL function `addEmployee(?)` that takes an `Employee` object as an `IN` parameter and adds it to the `PERSONNEL` table. In this example, `emp` is a valid `Employee` object.

1. Prepare an `OracleCallableStatement` to call the `addEmployee(?)` function.

```
OracleCallableStatement ocs =
  (OracleCallableStatement) conn.prepareCall("{ call addEmployee(?) }");
```

2. Use `setObject()` to pass the `emp` object as an `IN` parameter to the callable statement. Then, execute the statement.

```
ocs.setObject(1, emp);
ocs.execute();
```

Writing Data to an Oracle Object Using a SQLData Implementation

This section describes the steps in writing data to an Oracle object from your Java application when you choose the `SQLData` implementation for your custom object class.

This description assumes you have already defined the Oracle object type, created the corresponding Java class, and updated the type map to define the mapping between the Oracle object and the Java class.

1. If you have `set` methods in your custom object class, then use them to write data from Java variables in your application to attributes of your Java datatype object.

   ```
   emp.setEmpName(empname);
   emp.setEmpNum(empnumber);
   ```

   This statement uses the `emp` object and the `empname` and `empnumber` variables assigned in "Reading SQLData Objects from a Result Set" on page 13-13.

2. Prepare a statement that updates an Oracle object in a row of a database table, as appropriate, using the data provided in your Java datatype object.

   ```
   PreparedStatement pstmt = conn.prepareStatement
                             ("INSERT INTO PERSONNEL VALUES (?)");
   ```

   This assumes `conn` is your connection object.

3. Use the `setObject()` method of the prepared statement to bind your Java datatype object to the prepared statement.

   ```
   pstmt.setObject(1, emp);
   ```

4. Execute the statement, which updates the database.

   ```
   pstmt.executeUpdate();
   ```

Understanding the ORAData Interface

One of the choices in making an Oracle object and its attribute data available to Java applications is to create a custom object class that implements the `oracle.sql.ORAData` and `oracle.sql.ORADataFactory` interfaces (or you can implement `ORADataFactory` in a separate class). The `ORAData` and `ORADataFactory` interfaces are supplied by Oracle and are not a part of the JDBC standard.

> **Note:** The JPublisher utility supports the generation of classes that implement the `ORAData` and `ORADataFactory` interfaces. See "Using JPublisher to Create Custom Object Classes" on page 13-32.

Understanding ORAData Features

The `ORAData` interface has these advantages:

- It recognizes Oracle extensions to the JDBC; `ORAData` uses `oracle.sql.Datum` types directly.
- It does not require a type map to specify the names of the Java custom classes you want to create.
- It provides better performance: `ORAData` works directly with `Datum` types, the internal format the driver uses to hold Oracle objects.

The ORAData and ORADataFactory interfaces do the following:

- The toDatum() method of the ORAData class transforms the data into an oracle.sql.* representation.
- ORADataFactory specifies a create() method equivalent to a constructor for your custom object class. It creates and returns a ORAData instance. The JDBC driver uses the create() method to return an instance of the custom object class to your Java application or applet. It takes as input an oracle.sql.Datum object and an integer indicating the corresponding SQL typecode as specified in the OracleTypes class.

ORAData and ORADataFactory have the following definitions:

```
public interface ORAData
{
    Datum toDatum (OracleConnection conn) throws SQLException;
}

public interface ORADataFactory
{
    ORAData create (Datum d, int sql_Type_Code) throws SQLException;
}
```

Where *conn* represents the Connection object, *d* represents an object of type oracle.sql.Datum, and *sql_Type_Code* represents the SQL typecode (from the standard Types or OracleTypes class) of the Datum object.

Retrieving and Inserting Object Data

The JDBC drivers provide the following methods to retrieve and insert object data as instances of ORAData.

To retrieve object data:

- Use the Oracle-specific OracleResultSet class getORAData() method (assume an OracleResultSet object ors):

  ```
  ors.getORAData (int col_index, ORADataFactory factory);
  ```

  This method takes as input the column index of the data in your result set, and a ORADataFactory instance. For example, you can implement a getORAFactory() method in your custom object class to produce the ORADataFactory instance to input to getORAData(). The type map is not required when using Java classes that implement ORAData.

or:

- Use the standard getObject(*index*, *map*) method specified by the ResultSet interface to retrieve data as instances of ORAData. In this case, you must have an entry in the type map that identifies the factory class to be used for the given object type, and its corresponding SQL type name.

To insert object data:

- Use the Oracle-specific OraclePreparedStatement class setORAData() method (assume an OraclePreparedStatement object ops):

  ```
  ops.setORAData (int bind_index, ORAData custom_obj);
  ```

  This method takes as input the parameter index of the bind variable and the name of the object containing the variable.

or:

- Use the standard `setObject()` method specified by the `PreparedStatement` interface. You can also use this method, in its different forms, to insert `ORAData` instances without requiring a type map.

The following sections describe the `getORAData()` and `setORAData()` methods.

To continue the example of an Oracle object `EMPLOYEE`, you might have something like the following in your Java application:

```
ORAData datum = ors.getORAData(1, Employee.getORAFactory());
```

In this example, `ors` is an Oracle result set, `getORAData()` is a method in the `OracleResultSet` class used to retrieve a `ORAData` object, and the `EMPLOYEE` is in column 1 of the result set. The static `Employee.getORAFactory()` method will return a `ORADataFactory` to the JDBC driver. The JDBC driver will call `create()` from this object, returning to your Java application an instance of the `Employee` class populated with data from the result set.

Notes:

- `ORAData` and `ORADataFactory` are defined as separate interfaces so that different Java classes can implement them if you wish (such as an `Employee` class and an `EmployeeFactory` class).
- To use the `ORAData` interface, your custom object classes must import `oracle.sql.*` (or at least `ORAData`, `ORADataFactory`, and `Datum`).

Reading and Writing Data with a ORAData Implementation

This section describes how to read data from an Oracle object or write data to an Oracle object if your corresponding Java class implements `ORAData`.

Reading Data from an Oracle Object Using a ORAData Implementation

This section summarizes the steps in reading data from an Oracle object into your Java application. These steps apply whether you implement `ORAData` manually or use JPublisher to produce your custom object classes.

These steps assume you have already defined the Oracle object type, created the corresponding custom object class or had JPublisher create it for you, and defined a statement object `stmt`.

1. Query the database to read the Oracle object into a result set, casting to an Oracle result set.

   ```
   OracleResultSet ors = (OracleResultSet)stmt.executeQuery
                         ("SELECT Emp_col FROM PERSONNEL");
   ```

   Where `PERSONNEL` is a one-column table. The column name is `Emp_col` of type `Employee_object`.

2. Use the `getORAData()` method of your Oracle result set to populate an instance of your custom object class with data from one row of the result set. The `getORAData()` method returns an `oracle.sql.ORAData` object, which you can cast to your specific custom object class.

```
if (ors.next())
   Employee emp = (Employee)ors.getORAData(1, Employee.getORAFactory());
```

or:

```
if (ors.next())
   ORAData datum = ors.getORAData(1, Employee.getORAFactory());
```

This example assumes that `Employee` is the name of your custom object class and `ors` is the name of your `OracleResultSet` object.

In case you do not want to use `getORAData()`, the JDBC drivers let you use the `getObject()` method of a standard JDBC `ResultSet` to retrieve `ORAData` data. However, you must have an entry in the type map that identifies the factory class to be used for the given object type, and its corresponding SQL type name.

For example, if the SQL type name for your object is `EMPLOYEE`, then the corresponding Java class is `Employee`, which will implement `ORAData`. The corresponding Factory class is `EmployeeFactory`, which will implement `ORADataFactory`.

Use this statement to declare the `EmployeeFactory` entry for your type map:

```
map.put ("EMPLOYEE", Class.forName ("EmployeeFactory"));
```

Then use the form of `getObject()` where you specify the map object:

```
Employee emp = (Employee) rs.getObject (1, map);
```

If the connection's default type map already has an entry that identifies the factory class to be used for the given object type, and its corresponding SQL type name, then you can use this form of `getObject()`:

```
Employee emp = (Employee) rs.getObject (1);
```

3. If you have `get` methods in your custom object class, use them to read data from your object attributes into Java variables in your application. For example, if `EMPLOYEE` has `EmpName` of type `CHAR` and `EmpNum` (employee number) of type `NUMBER`, provide a `getEmpName()` method that returns a Java string and a `getEmpNum()` method that returns an integer. Then invoke them in your Java application as follows:

```
String empname = emp.getEmpName();
int empnumber = emp.getEmpNum();
```

> **Note:** Alternatively, you can fetch data into a callable statement object. The `OracleCallableStatement` class also has a `getORAData()` method.

Writing Data to an Oracle Object Using a ORAData Implementation

This section summarizes the steps in writing data to an Oracle object from your Java application. These steps apply whether you implement `ORAData` manually or use JPublisher to produce your custom object classes.

These steps assume you have already defined the Oracle object type and created the corresponding custom object class (or had JPublisher create it for you).

> **Note:** The type map is not used when you are performing database `INSERT` and `UPDATE` operations.

1. If you have `set` methods in your custom object class, then use them to write data from Java variables in your application to attributes of your Java datatype object.

   ```
   emp.setEmpName(empname);
   emp.setEmpNum(empnumber);
   ```

   This statement uses the `emp` object and the `empname` and `empnumber` variables defined in "Reading Data from an Oracle Object Using a ORAData Implementation" on page 13-17.

2. Write an Oracle prepared statement that updates an Oracle object in a row of a database table, as appropriate, using the data provided in your Java datatype object.

   ```
   OraclePreparedStatement opstmt = conn.prepareStatement
      ("UPDATE PERSONNEL SET Employee = ? WHERE Employee.EmpNum = 28959);
   ```

   This assumes `conn` is your `Connection` object.

3. Use the `setORAData()` method of the Oracle prepared statement to bind your Java datatype object to the prepared statement.

   ```
   opstmt.setORAData(1, emp);
   ```

   The `setORAData()` method calls the `toDatum()` method of the custom object class instance to retrieve an `oracle.sql.STRUCT` object that can be written to the database.

   In this step you could also use the `setObject()` method to bind the Java datatype. For example:

   ```
   opstmt.setObject(1,emp);
   ```

> **Note:** You can use your Java datatype objects as either `IN` or `OUT` bind variables.

Additional Uses for ORAData

The `ORAData` interface offers far more flexibility than the `SQLData` interface. The `SQLData` interface is designed to let you customize the mapping of only Oracle object types (SQL object types) to Java types of your choice. Implementing the `SQLData` interface lets the JDBC driver populate fields of a custom Java class instance from the original SQL object data, and the reverse, after performing the appropriate conversions between Java and SQL types.

The `ORAData` interface goes beyond supporting the customization of Oracle object types to Java types. It lets you provide a mapping between Java object types and *any* SQL type supported by the `oracle.sql` package.

It might be useful to provide custom Java classes to wrap `oracle.sql.*` types and perhaps implement customized conversions or functionality as well. The following are some possible scenarios:

- to perform encryption and decryption or validation of data
- to perform logging of values that have been read or are being written
- to parse character columns (such as character fields containing URL information) into smaller components
- to map character strings into numeric constants
- to map data into more desirable Java formats (such as mapping a `DATE` field to `java.util.Date` format)
- to customize data representation (for example, data in a table column is in feet but you want it represented in meters after it is selected)
- to serialize and deserialize Java objects—into or out of `RAW` fields, for example

For example, use `ORAData` to store instances of Java objects that do not correspond to a particular SQL object type in the database in columns of SQL type `RAW`. The `create()` method in `ORADataFactory` would have to implement a conversion from an object of type `oracle.sql.RAW` to the desired Java object. The `toDatum()` method in `ORAData` would have to implement a conversion from the Java object to an `oracle.sql.RAW` object. This can be done, for example, by using Java serialization.

Upon retrieval, the JDBC driver transparently retrieves the raw bytes of data in the form of an `oracle.sql.RAW` and calls the `ORADataFactory`'s `create()` method to convert the `oracle.sql.RAW` object to the desired Java class.

When you insert the Java object into the database, you can simply bind it to a column of type `RAW` to store it. The driver transparently calls the `ORAData.toDatum()` method to convert the Java object to an `oracle.sql.RAW` object. This object is then stored in a column of type `RAW` in the database.

Support for the `ORAData` interfaces is also highly efficient because the conversions are designed to work using `oracle.sql.*` formats, which happen to be the internal formats used by the JDBC drivers. Moreover, the type map, which is necessary for the `SQLData` interface, is not required when using Java classes that implement `ORAData`. For more information on why classes that implement `ORAData` do not need a type map, see "Understanding the ORAData Interface" on page 13-15.

The Deprecated CustomDatum Interface

After the `oracle.jdbc` interfaces were introduced in Oracle9*i* as an alternative to the `oracle.jdbc.driver` classes, the `oracle.sql.CustomDatum` and `oracle.sql.CustomDatumFactory` interfaces, formerly used to access customized objects, are deprecated. We recommend you use the new interfaces—`oracle.sql.ORAData` and `oracle.sql.ORADataFactory`.

The following are the specifications for the `CustomDatum` and `CustomDatumFactory` interfaces:

```
public interface CustomDatum
{
  oracle.sql.Datum toDatum(
    oracle.jdbc.driver.OracleConnection c
  ) throws SQLException ;

// The following is expected to be present in an
```

```
// implementation:
//
// - Definition of public static fields for
//   _SQL_TYPECODE, _SQL_NAME and  _SQL_BASETYPE.
//   (See Oracle Jdbc documentation for details.)
//
// - Definition of
//   public static CustomDatumFactory
//     getFactory();
//
}

public interface CustomDatumFactory
{
  oracle.sql.CustomDatum create(
    oracle.sql.Datum d, int sqlType
    ) throws SQLException;
}
```

Object-Type Inheritance

Object-type inheritance allows a new object type to be created by extending another object type. The new object type is then a subtype of the object type from which it extends. The subtype automatically inherits all the attributes and methods defined in the supertype. The subtype can add attributes and methods, and overload or override methods inherited from the supertype.

Object-type inheritance introduces *substitutability*. Substitutability is the ability of a slot declared to hold a value of type `T` to do so in addition to any subtype of type `T`. Oracle JDBC drivers handle substitutability transparently.

A database object is returned with its most specific type without losing information. For example, if the `STUDENT_T` object is stored in a `PERSON_T` slot, the Oracle JDBC driver returns a Java object that represents the `STUDENT_T` object.

Creating Subtypes

Create custom object classes if you want to have Java classes that explicitly correspond to the Oracle object types. (See "Creating and Using Custom Object Classes for Oracle Objects" on page 13-7.) If you have a hierarchy of object types, you may want a corresponding hierarchy of Java classes.

The most common way to create a database subtype in JDBC is to pass the extended SQL `CREATE TYPE` command to the `execute()` method of the `java.sql.Statement` interface. For example, to create a type inheritance hierarchy for:

```
PERSON_T
|
STUDENT_T
|
PARTTIMESTUDENT_T
```

the JDBC code can be:

```
Statement s = conn.createStatement();
s.execute ("CREATE TYPE Person_T (SSN NUMBER, name VARCHAR2(30),
  address VARCHAR2(255))");
s.execute ("CREATE TYPE Student_T UNDER Person_t (deptid NUMBER,
  major VARCHAR2(100))");
s.execute ("CREATE TYPE PartTimeStudent_t UNDER Student_t (numHours NUMBER)");
```

In the following code, the `"foo"` member procedure in type `ST` is overloaded and the member procedure `"print"` overwrites the copy it inherits from type `T`.

```
CREATE TYPE T AS OBJECT (...,
  MEMBER PROCEDURE foo(x NUMBER),
  MEMBER PROCEDURE Print(),
  ...
  NOT FINAL;

CREATE TYPE ST UNDER T (...,
  MEMBER PROCEDURE foo(x DATE),          <-- overload "foo"
  OVERRIDING MEMBER PROCEDURE Print(),    <-- override "print"
  STATIC FUNCTION bar(...) ...
  ...
  );
```

Once the subtypes have been created, they can be used as both columns of a base table as well as attributes of a object type. For complete details on the syntax to create subtypes, see the *Oracle Database Application Developer's Guide - Object-Relational Features* for details.

Implementing Customized Classes for Subtypes

In most cases, a customized Java class represents a database object type. When you create a customized Java class for a subtype, the Java class can either mirror the database object type hierarchy or not.

You can use either the `ORAData` or `SQLData` solution in creating classes to map to the hierarchy of object types.

Use of ORAData for Type Inheritance Hierarchy

Customized mapping where Java classes implement the `oracle.sql.ORAData` interface is the recommended mapping. (See "Relative Advantages of ORAData versus SQLData" on page 13-8.) `ORAData` mapping requires the JDBC application to implement the `ORAData` and `ORADataFactory` interfaces. The class implementing the `ORADataFactory` interface contains a factory method that produces objects. Each object represents a database object.

The hierarchy of the class implementing the `ORAData` interface can mirror the database object type hierarchy. For example, the Java classes mapping to `PERSON_T` and `STUDENT_T` are as follows:

Person.java using ORAData Code for the `Person.java` class which implements the `ORAData` and `ORADataFactory` interfaces:

```
class Person implements ORAData, ORADataFactory
{
  static final Person _personFactory = new Person();

  public NUMBER ssn;
```

```
  public CHAR name;
  public CHAR address;

  public static ORADataFactory getORADataFactory()
  {
    return _personFactory;
  }

  public Person () {}

  public Person(NUMBER ssn, CHAR name, CHAR address)
  {
    this.ssn = ssn;
    this.name = name;
    this.address = address;
  }

  public Datum toDatum(OracleConnection c) throws SQLException
  {
    StructDescriptor sd =
      StructDescriptor.createDescriptor("SCOTT.PERSON_T", c);
    Object [] attributes = { ssn, name, address };
    return new STRUCT(sd, c, attributes);
  }

  public ORAData create(Datum d, int sqlType) throws SQLException
  {
    if (d == null) return null;
    Object [] attributes = ((STRUCT) d).getOracleAttributes();
    return new Person((NUMBER) attributes[0],
                      (CHAR) attributes[1],
                      (CHAR) attributes[2]);
  }
}
```

Student.java extending Person.java Code for the `Student.java` class which extends the `Person.java` class:

```
class Student extends Person
{
  static final Student _studentFactory = new Student ();

  public NUMBER deptid;
  public CHAR major;

  public static ORADataFactory getORADataFactory()
  {
    return _studentFactory;
  }

  public Student () {}

  public Student (NUMBER ssn, CHAR name, CHAR address,
                  NUMBER deptid, CHAR major)
  {
    super (ssn, name, address);
    this.deptid = deptid;
    this.major = major;
  }
```

```
  public Datum toDatum(OracleConnection c) throws SQLException
  {
    StructDescriptor sd =
      StructDescriptor.createDescriptor("SCOTT.STUDENT_T", c);
    Object [] attributes = { ssn, name, address, deptid, major };
    return new STRUCT(sd, c, attributes);
  }

  public CustomDatum create(Datum d, int sqlType) throws SQLException
  {
    if (d == null) return null;
    Object [] attributes = ((STRUCT) d).getOracleAttributes();
    return new Student((NUMBER) attributes[0],
                       (CHAR) attributes[1],
                       (CHAR) attributes[2],
                       (NUMBER) attributes[3],
                       (CHAR) attributes[4]);
  }
}
```

Customized classes that implement the `ORAData` interface do not have to mirror the database object type hierarchy. For example, you could have declared the above class, `Student`, without a superclass. In this case, `Student` would contain fields to hold the inherited attributes from `PERSON_T` as well as the attributes declared by `STUDENT_T`.

ORADataFactory Implementation The JDBC application uses the factory class in querying the database to return instances of `Person` or its subclasses, as in the following example:

```
ResultSet rset = stmt.executeQuery ("select person from tab1");
while (rset.next())
{
  Object s = rset.getORAData (1, PersonFactory.getORADataFactory());
  ...
}
```

A class implementing the `ORADataFactory` interface should be able to produce instances of the associated custom object type, as well as instances of any subtype, or at least all the types you expect to support.

In the following example, the `PersonFactory.getORADataFactory()` method returns a factory that can handle `PERSON_T`, `STUDENT_T`, and `PARTTIMESTUDENT_T` objects (by returning `person`, `student`, or `parttimestudent` Java instances).

```
class PersonFactory implements ORADataFactory
{
  static final PersonFactory _factory = new PersonFactory ();

  public static ORADataFactory getORADataFactory()
  {
    return _factory;
  }

  public ORAData create(Datum d, int sqlType) throws SQLException
  {
    STRUCT s = (STRUCT) d;
    if (s.getSQLTypeName ().equals ("SCOTT.PERSON_T"))
      return Person.getORADataFactory ().create (d, sqlType);
    else if (s.getSQLTypeName ().equals ("SCOTT.STUDENT_T"))
```

```
      return Student.getORADataFactory ().create(d, sqlType);
    else if (s.getSQLTypeName ().equals ("SCOTT.PARTTIMESTUDENT_T"))
      return ParttimeStudent.getORADataFactory ().create(d, sqlType);
    else
      return null;
  }
}
```

The following example assumes a table tabl1, such as the following:

```
CREATE TABLE tabl1 (idx NUMBER, person PERSON_T);
INSERT INTO tabl1 VALUES (1, PERSON_T (1000, 'Scott', '100 Oracle Parkway'));
INSERT INTO tabl1 VALUES (2, STUDENT_T (1001, 'Peter', '200 Oracle Parkway', 101,
'CS'));
INSERT INTO tabl1 VALUES (3, PARTTIMESTUDENT_T (1002, 'David', '300 Oracle
Parkway', 102, 'EE'));
```

Use of SQLData for Type Inheritance Hierarchy

The customized classes that implement the `java.sql.SQLData` interface can mirror the database object type hierarchy. The `readSQL()` and `writeSQL()` methods of a subclass cascade each call to the corresponding methods in the superclass in order to read or write the superclass attributes before reading or writing the subclass attributes. For example, the Java classes mapping to `PERSON_T` and `STUDENT_T` are as follows:

Person.java using SQLData Code for the `Person.java` class which implements the `SQLData` interface:

```
import java.sql.*;

public class Person implements SQLData
{
  private String sql_type;
  public int ssn;
  public String name;
  public String address;

  public Person () {}

  public String getSQLTypeName() throws SQLException { return sql_type; }

  public void readSQL(SQLInput stream, String typeName) throws SQLException
  {
    sql_type = typeName;
    ssn = stream.readInt();
    name = stream.readString();
    address = stream.readString();
  }

  public void writeSQL(SQLOutput stream) throws SQLException
  {
    stream.writeInt (ssn);
    stream.writeString (name);
    stream.writeString (address);
  }
}
```

Student.java extending Student.java Code for the `Student.java` class which extends the `Person.java` class:

```
import java.sql.*;

public class Student extends Person
{
  private String sql_type;
  public int deptid;
  public String major;

  public Student () { super(); }

  public String getSQLTypeName() throws SQLException { return sql_type; }

  public void readSQL(SQLInput stream, String typeName) throws SQLException
  {
    super.readSQL (stream, typeName);    // read supertype attributes
    sql_type = typeName;
    deptid = stream.readInt();
    major = stream.readString();
  }

  public void writeSQL(SQLOutput stream) throws SQLException
  {
    super.writeSQL (stream);        // write supertype
                                    // attributes
    stream.writeInt (deptid);
    stream.writeString (major);
  }
}
```

Customized classes that implement the `SQLData` interface do not have to mirror the database object type hierarchy. For example, you could have declared the above class, `Student`, without a superclass. In this case, `Student` would contain fields to hold the inherited attributes from `PERSON_T` as well as the attributes declared by `STUDENT_T`.

Student.java using SQLData Code for the `Student.java` class which does not extend the `Person.java` class, but implements the SQLData interface directly:

```
import java.sql.*;

public class Student implements SQLData
{
  private String sql_type;

  public int ssn;
  public String name;
  public String address;
  public int deptid;
  public String major;

  public Student () {}

  public String getSQLTypeName() throws SQLException { return sql_type; }

  public void readSQL(SQLInput stream, String typeName) throws SQLException
  {
    sql_type = typeName;
    ssn = stream.readInt();
```

```
    name = stream.readString();
    address = stream.readString();
    deptid = stream.readInt();
    major = stream.readString();
  }

  public void writeSQL(SQLOutput stream) throws SQLException
  {
    stream.writeInt (ssn);
    stream.writeString (name);
    stream.writeString (address);
    stream.writeInt (deptid);
    stream.writeString (major);
  }
}
```

JPublisher Utility

Even though you can manually create customized classes that implement the `SQLData`, `ORAData`, and `ORADataFactory` interfaces, it is recommended that you use Oracle JPublisher to automatically generate these classes. The customized classes generated by Oracle JPublisher that implement the `SQLData`, `ORAData`, and `ORADataFactory` interfaces, can mirror the inheritance hierarchy.

To learn more about JPublisher, see "Using JPublisher to Create Custom Object Classes" on page 13-32 and the *Oracle Database JPublisher User's Guide.*

Retrieving Subtype Objects

In a typical JDBC application, a subtype object is returned as one of the following:

- A query result
- A PL/SQL `OUT` parameter
- A type attribute

You can use either the default (`oracle.sql.STRUCT`), `ORAData`, or `SQLData` mapping to retrieve a subtype.

Using Default Mapping

By default, a database object is returned as an instance of the `oracle.sql.STRUCT` class. This instance may represent an object of either the declared type or subtype of the declared type. If the `STRUCT` class represents a subtype object in the database, then it contains the attributes of its supertype as well as those defined in the subtype.

The Oracle JDBC driver returns database objects in their most specific type. The JDBC application can use the `getSQLTypeName()` method of the `STRUCT` class to determine the SQL type of the `STRUCT` object. The following code shows this:

```
// tab1.person column can store PERSON_T, STUDENT_T and PARTIMESTUDENT_T objects
ResultSet rset = stmt.executeQuery ("select person from tab1");
while (rset.next())
{
  oracle.sql.STRUCT s = (oracle.sql.STRUCT) rset.getObject(1);
  if (s != null)
    System.out.println (s.getSQLTypeName());    // print out the type name which
    // may be SCOTT.PERSON_T, SCOTT.STUDENT_T or SCOTT.PARTTIMESTUDENT_T
}
```

Using SQLData Mapping

With `SQLData` mapping, the JDBC driver returns the database object as an instance of the class implementing the `SQLData` interface.

To use `SQLData` mapping in retrieving database objects, do the following:

1. Implement the wrapper classes that implement the `SQLData` interface for the desired object types.
2. Populate the connection type map with entries that specify what custom Java type corresponds to each Oracle object type (SQL object type).
3. Use the `getObject()` method to access the SQL object values.

   The JDBC driver checks the type map for a entry match. If one exists, the driver returns the database object as an instance of the class implementing the `SQLData` interface.

The following code shows the whole SQLData customized mapping process:

```
// The JDBC application developer implements Person.java for PERSON_T,
// Student.java for STUDENT_T
// and ParttimeStudent.java for PARTTIMESTUDEN_T.

Connection conn = ...;  // make a JDBC connection

// obtains the connection typemap
java.util.Map map = conn.getTypeMap ();

// populate the type map
map.put ("SCOTT.PERSON_T", Class.forName ("Person"));
map.put ("SCOTT.STUDENT_T", Class.forName ("Student"));
map.put ("SCOTT.PARTTIMESTUDENT_T", Class.forName ("ParttimeStudent"));

// tab1.person column can store PERSON_T, STUDENT_T and PARTTIMESTUDENT_T objects
ResultSet rset = stmt.executeQuery ("select person from tab1");
while (rset.next())
{
  // "s" is instance of Person, Student or ParttimeStudent
  Object s = rset.getObject(1);

  if (s != null)
  {
    if (s instanceof Person)
      System.out.println ("This is a Person");
    else if (s instanceof Student)
      System.out.println ("This is a Student");
    else if (s instanceof ParttimeStudent)
      System.out.pritnln ("This is a PartimeStudent");
    else
      System.out.println ("Unknown type");
  }
}
```

The JDBC drivers check the connection type map for each call to the following:

- `getObject()` method of the `java.sql.ResultSet` and `java.sql.CallableStatement` interfaces
- `getAttribute()` method of the `java.sql.Struct` interface
- `getArray()` method of the `java.sql.Array` interface

- `getValue()` method of the `oracle.sql.REF` interface

Using ORAData Mapping

With `ORAData` mapping, the JDBC driver returns the database object as an instance of the class implementing the `ORAData` interface.

The Oracle JDBC driver needs to be informed of what Java class is mapped to the Oracle object type. The following are the two ways to inform the Oracle JDBC drivers:

- The JDBC application uses the `getORAData(int idx, ORADataFactory f)` method to access database objects. The second parameter of the `getORAData()` method specifies an instance of the factory class that produces the customized class. The `getORAData()` method is available in the `OracleResultSet` and `OracleCallableStatement` classes.
- The JDBC application populates the connection type map with entries that specify what custom Java type corresponds to each Oracle object type. The `getObject()` method is used to access the Oracle object values.

The first approach avoids the type-map lookup and is therefore more efficient. However, the second approach involves the use of the standard `getObject()` method. The following code example demonstrates the first approach:

```
// tab1.person column can store both PERSON_T and STUDENT_T objects
ResultSet rset = stmt.executeQuery ("select person from tab1");
while (rset.next())
{
  Object s = rset.getORAData (1, PersonFactory.getORADataFactory());
  if (s != null)
  {
    if (s instanceof Person)
      System.out.println ("This is a Person");
    else if (s instanceof Student)
      System.out.println ("This is a Student");
    else if (s instanceof ParttimeStudent)
      System.out.pritnln ("This is a PartimeStudent");
    else
      System.out.println ("Unknown type");
  }
}
```

Creating Subtype Objects

There are cases where JDBC applications create database subtype objects with JDBC drivers. These objects are sent either to the database as bind variables or are used to exchange information within the JDBC application.

With customized mapping, the JDBC application creates either `SQLData`- or `ORAData`-based objects (depending on which approach you choose) to represent database subtype objects. With default mapping, the JDBC application creates `STRUCT` objects to represent database subtype objects. All the data fields inherited from the supertype as well as all the fields defined in the subtype must have values. The following code demonstrates this:

```
Connection conn = ...    // make a JDBC connection
StructDescriptor desc = StructDescriptor.createDescriptor
("SCOTT.PARTTIMESTUDENT", conn);
Object[] attrs = {
```

```
  new Integer(1234), "Scott", "500 Oracle Parkway", // data fields defined in
                                                    // PERSON_T
  new Integer(102), "CS",                           // data fields defined in
                                                    // STUDENT_T
  new Integer(4)                                    // data fields defined in
                                                    // PARTTIMESTUDENT_T
};
STRUCT s = new STRUCT (desc, conn, attrs);
```

s is initialized with data fields inherited from PERSON_T and STUDENT_T, and data fields defined in PARTTIMESTUDENT_T.

Sending Subtype Objects

In a typical JDBC application, a Java object that represents a database object is sent to the databases as one of the following:

- A Data Manipulation Language (DML) bind variable
- A PL/SQL IN parameter
- An object type attribute value

The Java object can be an instance of the STRUCT class or an instance of the class implementing either the SQLData or ORAData interface. The Oracle JDBC driver will convert the Java object into the linearized format acceptable to the database SQL engine. Binding a subtype object is the same as binding a normal object.

Accessing Subtype Data Fields

While the logic to access subtype data fields is part of the customized class, this logic for default mapping is defined in the JDBC application itself. The database objects are returned as instances of the oracle.sql.STRUCT class. The JDBC application needs to call one of the following access methods in the STRUCT class to access the data fields:

- `Object[] getAttribute()`
- `oracle.sql.Datum[] getOracleAttribute()`

Subtype Data Fields from the getAttribute() Method

The getAttribute() method of the java.sql.Struct interface is used in JDBC 2.0 to access object data fields. This method returns a java.lang.Object array, where each array element represents an object attribute. You can determine the individual element type by referencing the corresponding attribute type in the JDBC conversion matrix, as listed in Table 10–1, " Oracle Datatype Classes". For example, a SQL NUMBER attribute is converted to a java.math.BigDecimal object. The getAttribute() method returns all the data fields defined in the supertype of the object type as well as data fields defined in the subtype. The supertype data fields are listed first followed by the subtype data fields.

Subtype Data Fields from the getOracleAttribute() Method

The getOracleAttribute() method is an Oracle extension method and is more efficient than the getAttribute() method. The getOracleAttribute() method returns an oracle.sql.Datum array to hold the data fields. Each element in the oracle.sql.Datum array represents an attribute. You can determine the individual element type by referencing the corresponding attribute type in the Oracle conversion matrix, as listed in Table 10–1, " Oracle Datatype Classes". For example, a SQL NUMBER

attribute is converted to an `oracle.sql.NUMBER` object. The `getOracleAttribute()` method returns all the attributes defined in the supertype of the object type, as well as attributes defined in the subtype. The supertype data fields are listed first followed by the subtype data fields.

The following code shows the use of the `getAttribute()` method:

```
// tab1.person column can store PERSON_T, STUDENT_T and PARTIMESTUDENT_T objects
ResultSet rset = stmt.executeQuery ("select person from tab1");
while (rset.next())
{
  oracle.sql.STRUCT s = (oracle.sql.STRUCT) rset.getObject(1);
  if (s != null)
  {
    String sqlname = s.getSQLTypeName();

    Object[] attrs = s.getAttribute();

    if (sqlname.equals ("SCOTT.PERSON")
    {
      System.out.println ("ssn="+((BigDecimal)attrs[0]).intValue());
      System.out.println ("name="+((String)attrs[1]));
      System.out.println ("address="+((String)attrs[2]));
    }
    else if (sqlname.equals ("SCOTT.STUDENT"))
    {
      System.out.println ("ssn="+((BigDecimal)attrs[0]).intValue());
      System.out.println ("name="+((String)attrs[1]));
      System.out.println ("address="+((String)attrs[2]));
      System.out.println ("deptid="+((BigDecimal)attrs[3]).intValue());
      System.out.println ("major="+((String)attrs[4]));
    }
    else if (sqlname.equals ("SCOTT.PARTTIMESTUDENT"))
    {
      System.out.println ("ssn="+((BigDecimal)attrs[0]).intValue());
      System.out.println ("name="+((String)attrs[1]));
      System.out.println ("address="+((String)attrs[2]));
      System.out.println ("deptid="+((BigDecimal)attrs[3]).intValue());
      System.out.println ("major="+((String)attrs[4]));
      System.out.println ("numHours="+((BigDecimal)attrs[5]).intValue());
    }
    else
      throw new Exception ("Invalid type name: "+sqlname);
  }
}
rset.close ();
stmt.close ();
conn.close ();
```

Inheritance Meta Data Methods

Oracle JDBC drivers provide a set of meta data methods to access inheritance properties. The inheritance meta data methods are defined in the `oracle.sql.StructDescriptor` and `oracle.jdbc.StructMetaData` classes.

The `oracle.sql.StructDescriptor` class provides the following inheritance meta data methods:

- `String[] getSubtypeNames()` : returns the SQL type names of the direct subtypes

- `boolean isFinalType()` : indicates whether the object type is a final type. An object type is `FINAL` if no subtypes can be created for this type; the default is `FINAL`, and a type declaration must have the `NOT FINAL` keyword to be "subtypable"
- `boolean isSubTyp()` : indicates whether the object type is a subtype.
- `boolean isInstantiable()` : indicates whether the object type is instantiable; an object type is `NOT INSTANTIABLE` if it is not possible to construct instances of this type
- `String getSupertypeName()` : returns the SQL type names of the direct supertype
- `int getLocalAttributeCount()` : returns the number of attributes defined in the subtype

The `StructMetaData` class provides inheritance meta data methods for subtype attributes; the `getMetaData()` method of the `StructDescriptor` class returns an instance of `StructMetaData` of the type. The `StructMetaData` class contains the following inheritance meta data methods:

- `int getLocalColumnCount()` : returns the number of attributes defined in the subtype, which is similar to the `getLocalAttributeCount()` method of the `StructDescriptor` class
- `boolean isInherited(int column)` : indicates whether the attribute is inherited; the *column* begins with 1

Using JPublisher to Create Custom Object Classes

A convenient way to create custom object classes, as well as other kinds of custom Java classes, is to use the Oracle JPublisher utility. It generates a full definition for a custom Java class, which you can instantiate to hold the data from an Oracle object. JPublisher-generated classes include methods to convert data from SQL to Java and from Java to SQL, as well as getter and setter methods for the object attributes.

This section offers a brief overview. For more information, see the *Oracle Database JPublisher User's Guide.*

JPublisher Functionality

You can direct JPublisher to create custom object classes that implement either the `SQLData` interface or the `ORAData` interface, according to how you set the JPublisher type mappings.

If you use the `ORAData` interface, JPublisher will also create a custom reference class to map to object references for the Oracle object type. If you use the `SQLData` interface, JPublisher will not produce a custom reference class; you would use standard `java.sql.Ref` instances instead.

If you want additional functionality, you can subclass the custom object class and add features as desired. When you run JPublisher, there is a command-line option for specifying both a generated class name and the name of the subclass you will implement. For the SQL-Java mapping to work properly, JPublisher must know the subclass name, which is incorporated into some of the functionality of the generated class.

Note: Hand-editing the JPublisher-generated class, instead of subclassing it, is not recommended. If you hand-edit this class and later have to re-run JPublisher for some reason, you would have to re-implement your changes.

JPublisher Type Mappings

JPublisher offers various choices for how to map user-defined types and their attribute types between SQL and Java. The rest of this section lists categories of SQL types and the mapping options available for each category.

For general information about SQL-Java type mappings, see "Datatype Mappings" on page 4-12.

For more information about JPublisher features or options, see the *Oracle Database JPublisher User's Guide.*

Categories of SQL Types

JPublisher categorizes SQL types into the following groups, with corresponding JPublisher options as noted:

- user-defined types (UDT)—Oracle objects, references, and collections

  Use the JPublisher `-usertypes` option to specify the type-mapping implementation for UDTs—either a standard `SQLData` implementation or an Oracle-specific `ORAData` implementation.

- numeric types—anything stored in the database as SQL type `NUMBER`

  Use the JPublisher `-numbertypes` option to specify type-mapping for numeric types.

- LOB types—SQL types `BLOB` and `CLOB`

  Use the JPublisher `-lobtypes` option to specify type-mapping for LOB types.

- built-in types—anything stored in the database as a SQL type not covered by the preceding categories; for example: `CHAR`, `VARCHAR2`, `LONG`, and `RAW`

  Use the JPublisher `-builtintypes` option to specify type-mapping for built-in types.

Type-Mapping Modes

JPublisher defines the following type-mapping modes, two of which apply to numeric types only:

- JDBC mapping (setting `jdbc`)—Uses standard default mappings between SQL types and Java native types. For a custom object class, uses a `SQLData` implementation.
- Oracle mapping (setting `oracle`)—Uses corresponding `oracle.sql` types to map to SQL types. For a custom object, reference, or collection class, uses a `ORAData` implementation.
- object-JDBC mapping (for numeric types only) (setting `objectjdbc`)—This is an extension of JDBC mapping. Where relevant, object-JDBC mapping uses numeric object types from the standard `java.lang` package (such as `java.lang.Integer`, `Float`, and `Double`), instead of primitive Java types

(such as `int`, `float`, and `double`). The `java.lang` types are nullable, while the primitive types are not.

- `BigDecimal` mapping (for numeric types only) (setting `bigdecimal`)—Uses `java.math.BigDecimal` to map to all numeric attributes; appropriate if you are dealing with large numbers but do not want to map to the `oracle.sql.NUMBER` class.

  Note: Using `BigDecimal` mapping can significantly degrade performance.

Mapping the Oracle object type to Java

Use the JPublisher `-usertypes` option to determine how JPublisher will implement the custom Java class that corresponds to a Oracle object type:

- A setting of `-usertypes=oracle` (the default setting) instructs JPublisher to create a `ORAData` implementation for the custom object class.

  This will also result in JPublisher producing a `ORAData` implementation for the corresponding custom reference class.

- A setting of `-usertypes=jdbc` instructs JPublisher to create a `SQLData` implementation for the custom object class. No custom reference class can be created—you must use `java.sql.Ref` or `oracle.sql.REF` for the reference type.

The next section discusses type mapping options that you can use for object attributes.

Note: You can also use JPublisher with a `-usertypes=oracle` setting in creating `ORAData` implementations to map SQL collection types.

The `-usertypes=jdbc` setting is not valid for mapping SQL collection types. (The `SQLData` interface is intended only for mapping Oracle object types.)

Mapping Attribute Types to Java

If you do not specify mappings for the attribute types of the Oracle object type, JPublisher uses the following defaults:

- For numeric attribute types, the default mapping is object-JDBC.
- For LOB attribute types, the default mapping is Oracle.
- For built-in type attribute types, the default mapping is JDBC.

If you want alternate mappings, use the `-numbertypes`, `-lobtypes`, and `-builtintypes` options as necessary, depending on the attribute types you have and the mappings you desire.

If an attribute type is itself an Oracle object type, it will be mapped according to the `-usertypes` setting.

Important: Be especially aware that if you specify a `SQLData` implementation for the custom object class and want the code to be portable, you must be sure to use portable mappings for the attribute types. The defaults for numeric types and built-in types are portable, but for LOB types you must specify `-lobtypes=jdbc`.

Summary of SQL Type Categories and Mapping Settings

Table 13–1 summarizes JPublisher categories for SQL types, the mapping settings relevant for each category, and the default settings.

Table 13–1 JPublisher SQL Type Categories, Supported Settings, and Defaults

SQL Type Category	JPublisher Mapping Option	Mapping Settings	Default
UDT types	-usertypes	oracle, jdbc	oracle
numeric types	-numbertypes	oracle, jdbc, objectjdbc, bigdecimal	objectjdbc
LOB types	-lobtypes	oracle, jdbc	oracle
built-in types	-builtintypes	oracle, jdbc	jdbc

Note: The JPublisher `-mapping` option used in previous releases will be deprecated but is currently still supported. For information about how JPublisher converts -mapping option settings to settings for the new mapping options, see the *Oracle Database JPublisher User's Guide.*

Describing an Object Type

Oracle JDBC includes functionality to retrieve information about a structured object type regarding its attribute names and types. This is similar conceptually to retrieving information from a result set about its column names and types, and in fact uses an almost identical method.

Functionality for Getting Object Meta Data

The `oracle.sql.StructDescriptor` class, discussed earlier in "STRUCT Descriptors" on page 13-3 and "Steps in Creating StructDescriptor and STRUCT Objects" on page 13-4, includes functionality to retrieve meta data about a structured object type.

The `StructDescriptor` class has a `getMetaData()` method with the same functionality as the standard `getMetaData()` method available in result set objects. It returns a set of attribute information such as attribute names and types. Call this method on a `StructDescriptor` object to get meta data about the Oracle object type that the `StructDescriptor` object describes. (Remember that each structured object type must have an associated `StructDescriptor` object.)

The signature of the `StructDescriptor` class `getMetaData()` method is the same as the signature specified for `getMetaData()` in the standard `ResultSet` interface:

- `ResultSetMetaData getMetaData() throws SQLException`

However, this method actually returns an instance of `oracle.jdbc.StructMetaData`, a class that supports structured object meta data in the same way that the standard `java.sql.ResultSetMetaData` interface specifies support for result set meta data.

The `StructMetaData` class includes the following standard methods that are also specified by `ResultSetMetaData`:

- `String getColumnName(int column) throws SQLException`

  This returns a `String` that specifies the name of the specified attribute, such as "salary".

- `int getColumnType(int column) throws SQLException`

  This returns an `int` that specifies the typecode of the specified attribute, according to the `java.sql.Types` and `oracle.jdbc.OracleTypes` classes.

- `String getColumnTypeName(int column) throws SQLException`

  This returns a string that specifies the type of the specified attribute, such as `"BigDecimal"`.

- `int getColumnCount() throws SQLException`

  This returns the number of attributes in the object type.

As well as the following method, supported only by `StructMetaData`:

- `String getOracleColumnClassName(int column) throws SQLException`

  This returns the fully-qualified name of the `oracle.sql.Datum` subclass whose instances are manufactured if the `OracleResultSet` class `getOracleObject()` method is called to retrieve the value of the specified attribute. For example, "`oracle.sql.NUMBER`".

  To use the `getOracleColumnClassName()` method, you must cast the `ResultSetMetaData` object (that was returned by the `getMetaData()` method) to a `StructMetaData` object.

> **Note:** In all the preceding method signatures, "column" is something of a misnomer. Where you specify a "column" of 4, you really refer to the fourth attribute of the object.

Steps for Retrieving Object Meta Data

Use the following steps to obtain meta data about a structured object type:

1. Create or acquire a `StructDescriptor` instance that describes the relevant structured object type.
2. Call the `getMetaData()` method on the `StructDescriptor` instance.
3. Call the meta data getter methods as desired—`getColumnName()`, `getColumnType()`, and `getColumnTypeName()`.

> **Note:** If one of the structured object attributes is itself a structured object, repeat steps 1 through 3.

Example

The following method shows how to retrieve information about the attributes of a structured object type. This includes the initial step of creating a `StructDescriptor` instance.

```
//
// Print out the ADT's attribute names and types
//
void getAttributeInfo (Connection conn, String type_name) throws SQLException
{
  // get the type descriptor
  StructDescriptor desc = StructDescriptor.createDescriptor (type_name, conn);

  // get type meta data
  ResultSetMetaData md = desc.getMetaData ();

  // get # of attrs of this type
  int numAttrs = desc.length ();

  // temporary buffers
  String attr_name;
  int attr_type;
  String attr_typeName;

  System.out.println ("Attributes of "+type_name+" :");
  for (int i=0; i<numAttrs; i++)
  {
    attr_name = md.getColumnName (i+1);
    attr_type = md.getColumnType (i+1);
    System.out.println (" index"+(i+1)+" name="+attr_name+" type="+attr_type);

    // drill down nested object
    if (attrType == OracleTypes.STRUCT)
    {
      attr_typeName = md.getColumnTypeName (i+1);

      // recursive calls to print out nested object meta data
      getAttributeInfo (conn, attr_typeName);
    }
  }
}
```

14

Working with LOBs and BFILEs

This chapter describes how you use JDBC and the `oracle.sql.*` classes to access and manipulate LOB and BFILE locators and data, covering the following topics:

- Oracle Extensions for LOBs and BFILEs
- Working with BLOBs and CLOBs
- Shortcuts For Inserting and Retrieving CLOB Data
- Working With Temporary LOBs
- Using Open and Close With LOBs
- Working with BFILEs

Notes:

- At 10*g* Release 1 (10.1), the Oracle JDBC drivers support the JDBC 3.0 `java.sql.Clob` and `java.sql.Blob` interfaces. Certain Oracle extensions made in `oracle.sql.CLOB` and `oracle.sql.BLOB` before this release are no longer necessary and are deprecated. You should port your application to the standard JDBC 3.0 interface.
- Before Release 10g (10.1), the maximum size of a LOB was 2^{32} bytes. That restriction is removed at this release; the maximum size is now limited to the size of available physical storage. The Java LOB API has not changed.

Oracle Extensions for LOBs and BFILEs

LOBs ("large objects") are stored in a way that optimizes space and provides efficient access. The JDBC drivers provide support for two types of LOBs: BLOBs (unstructured binary data) and CLOBs (character data). BLOB and CLOB data is accessed and referenced by using a locator, which is stored in the database table and points to the BLOB or CLOB data, which is outside the table.

BFILEs are large binary data objects stored in operating system files outside of database tablespaces. These files use reference semantics. They can also be located on tertiary storage devices such as hard disks, CD-ROMs, PhotoCDs and DVDs. As with BLOBs and CLOBs, a BFILE is accessed and referenced by a locator which is stored in the database table and points to the BFILE data.

To work with LOB data, you must first obtain a LOB locator. Then you can read or write LOB data and perform data manipulation. The following sections also describe how to create and populate a LOB column in a table.

The JDBC drivers support these `oracle.sql.*` classes for BLOBs, CLOBs, and BFILEs:

- `oracle.sql.BLOB`
- `oracle.sql.CLOB`
- `oracle.sql.BFILE`

The `oracle.sql.BLOB` and `CLOB` classes implement the `java.sql.Blob` and `Clob` interfaces, respectively. By contrast, `BFILE` is an Oracle extension, without a corresponding `java.sql` interface.

Instances of these classes contain only the locators for these datatypes, not the data. After accessing the locators, you must perform some additional steps to access the data. These steps are described in "Reading and Writing BLOB and CLOB Data" on page 14-4 and "Reading BFILE Data" on page 14-16.

> **Note:** You cannot construct BLOB, CLOB, or BFILE objects in your JDBC application—you can only retrieve existing BLOBs, CLOBs, or BFILEs from the database or create them using the `createTemporary()` and `empty_lob()` methods.

Working with BLOBs and CLOBs

This section describes how to read and write data to and from binary large objects (BLOBs) and character large objects (CLOBs) in an Oracle database, using LOB locators.

For general information about LOBs and how to use them, see the *Oracle Database Application Developer's Guide - Large Objects*.

Getting and Passing BLOB and CLOB Locators

Standard as well as Oracle-specific getter and setter methods are available for retrieving or passing LOB locators from or to the database.

Retrieving BLOB and CLOB Locators

Given a standard JDBC result set (`java.sql.ResultSet`) or callable statement (`java.sql.CallableStatement`) that includes BLOB or CLOB locators, you can

access the locators by using standard getter methods, as follows. All the standard and Oracle-specific getter methods discussed here take either an `int` column index or a `String` column name as input.

- Under JDK 1.2.x and higher, you can use the standard `getBlob()` and `getClob()` methods, which return `java.sql.Blob` and `Clob` objects, respectively.

If you retrieve or cast the result set or callable statement to an `OracleResultSet` or `OracleCallableStatement` object, then you can use Oracle extensions as follows:

- You can use `getBLOB()` and `getCLOB()`, which return `oracle.sql.BLOB` and `CLOB` objects, respectively.
- You can also use the `getOracleObject()` method, which returns an `oracle.sql.Datum` object, and cast the output appropriately.

Example: Getting BLOB and CLOB Locators from a Result Set Assume the database has a table called `lob_table` with a column for a BLOB locator, `blob_col`, and a column for a CLOB locator, `clob_col`. This example assumes that you have already created the `Statement` object, `stmt`.

First, select the LOB locators into a standard result set, then get the LOB data into appropriate Java classes:

```
// Select LOB locator into standard result set.
ResultSet rs =
   stmt.executeQuery ("SELECT blob_col, clob_col FROM lob_table");
while (rs.next())
{
   // Get LOB locators into Java wrapper classes.
   java.sql.Blob blob = (java.sql.Blob)rs.getObject(1);
   java.sql.Clob clob = (java.sql.Clob)rs.getObject(2);
   (...process...)
}
```

The output is cast to `java.sql.Blob` and `Clob`. As an alternative, you can cast the output to `oracle.sql.BLOB` and `CLOB` to take advantage of extended functionality offered by the `oracle.sql.*` classes. For example, you can rewrite the above code to get the LOB locators as:

```
   // Get LOB locators into Java wrapper classes.
   oracle.sql.BLOB blob = (BLOB)rs.getObject(1);
   oracle.sql.CLOB clob = (CLOB)rs.getObject(2);
   (...process...)
```

Example: Getting a CLOB Locator from a Callable Statement The callable statement methods for retrieving LOBs are identical to the result set methods.

For example, if you have an `OracleCallableStatement` `ocs` that calls a function `func` that has a CLOB output parameter, then set up the callable statement as in the following example.

This example registers `OracleTypes.CLOB` as the typecode of the output parameter.

```
OracleCallableStatement ocs =
   (OracleCallableStatement)conn.prepareCall("{? = call func()}");
ocs.registerOutParameter(1, OracleTypes.CLOB);
ocs.execute();
oracle.sql.CLOB clob = ocs.getCLOB(1);
```

Passing BLOB and CLOB Locators

Given a standard JDBC prepared statement (`java.sql.PreparedStatement`) or callable statement (`java.sql.CallableStatement`), you can use standard setter methods to pass LOB locators, as follows. All the standard and Oracle-specific setter methods discussed here take an `int` parameter index and the LOB locator as input. You use the standard `setBlob()` and `setClob()` methods, which take `java.sql.Blob` and `Clob` locators as input.

> **Note:** If you pass a BLOB to a PL/SQL procedure, the BLOB must be no bigger than 32K - 7. If you pass a BLOB that exceeds this limit, you will receive a `SQLException`.

Given an Oracle-specific `OraclePreparedStatement` or `OracleCallableStatement`, then you can use Oracle extensions as follows:

- Use `setBLOB()` and `setCLOB()`, which take `oracle.sql.BLOB` and `CLOB` locators as input, respectively.
- Use the `setOracleObject()` method, which simply specifies an `oracle.sql.Datum` input.

Example: Passing a BLOB Locator to a Prepared Statement If you have an `OraclePreparedStatement` object `ops` and a BLOB named `my_blob`, then write the BLOB to the database as follows:

```
OraclePreparedStatement ops = (OraclePreparedStatement)conn.prepareStatement
                              ("INSERT INTO blob_table VALUES(?)");
ops.setBLOB(1, my_blob);
ops.execute();
```

Example: Passing a CLOB Locator to a Callable Statement If you have an `OracleCallableStatement` object `ocs` and a CLOB named `my_clob`, then input the CLOB to the stored procedure `proc` as follows:

```
OracleCallableStatement ocs =
   (OracleCallableStatement)conn.prepareCall("{call proc(?)}");
ocs.setClob(1, my_clob);
ocs.execute();
```

Reading and Writing BLOB and CLOB Data

Once you have a LOB locator, you can use JDBC methods to read and write the LOB data. LOB data is materialized as a Java array or stream. However, unlike most Java streams, a locator representing the LOB data is stored in the table. Thus, you can access the LOB data at any time during the life of the connection.

To read and write the LOB data, use the methods in the `oracle.sql.BLOB` or `oracle.sql.CLOB` class, as appropriate. These classes provide functionality such as reading from the LOB into an input stream, writing from an output stream into a LOB, determining the length of a LOB, and closing a LOB.

> **Notes:** To write LOB data, the application must acquire a write lock on the LOB object. One way to accomplish this is through a `SELECT FOR UPDATE`. Also, disable auto-commit mode.

To read and write LOB data, you can use these methods:

- To read from a BLOB, use the `setBinaryStream()` method of an `oracle.sql.BLOB` object to retrieve the entire `BLOB` as an input stream. This returns a `java.io.InputStream` object.

  As with any `InputStream` object, use one of the overloaded `read()` methods to read the LOB data, and use the `close()` method when you finish.

- To write to a BLOB, use the `setBinaryStream()` method of an `oracle.sql.BLOB` object to retrieve the BLOB as an output stream. This returns a `java.io.OutputStream` object to be written back to the BLOB.

  As with any `OutputStream` object, use one of the overloaded `write()` methods to update the LOB data, and use the `close()` method when you finish.

- To read from a CLOB, use the `getAsciiStream()` or `getCharacterStream()` method of an `oracle.sql.CLOB` object to retrieve the entire CLOB as an input stream. The `getAsciiStream()` method returns an ASCII input stream in a `java.io.InputStream` object. The `getCharacterStream()` method returns a `Unicode` input stream in a `java.io.Reader` object.

  As with any `InputStream` or `Reader` object, use one of the overloaded `read()` methods to read the LOB data, and use the `close()` method when you finish.

  You can also use the `getSubString()` method of `oracle.sql.CLOB` object to retrieve a subset of the CLOB as a character string of type `java.lang.String`.

- To write to a CLOB, use the `setAsciiStream()` or `setCharacterStream()` method of an `oracle.sql.CLOB` object to retrieve the CLOB as an output stream to be written back to the CLOB. The `setAsciiStream()` method returns an ASCII output stream in a `java.io.OutputStream` object. The `setCharacterStream()` method returns a `Unicode` output stream in a `java.io.Writer` object.

  As with any `Stream` or `Writer` object, use one of the overloaded `write()` methods to update the LOB data, and use the `flush()` and `close()` methods when you finish.

Notes:

- The stream "write" methods described in this section write directly to the database when you write to the output stream. You do *not* need to execute an `UPDATE` to write the data. CLOBs and BLOBs are transaction controlled. After writing to either, you must commit the transaction for the changes to be permanent. BFILEs are not transaction controlled. Once you write to them the changes are permanent, even if the transaction is rolled back, unless the external file system does something else.
- When writing to or reading from a CLOB, the JDBC drivers perform all character set conversions for you.

Example: Reading BLOB Data

Use the `setBinaryStream()` method of the `oracle.sql.BLOB` class to read BLOB data. The `setBinaryStream()` method reads the BLOB data into a binary stream.

The following example uses the `setBinaryStream()` method to read BLOB data into a byte stream and then reads the byte stream into a byte array (returning the number of bytes read, as well).

```
// Read BLOB data from BLOB locator.
InputStream byte_stream = my_blob.setBinaryStream(1L);
byte [] byte_array = new byte [10];
int bytes_read = byte_stream.read(byte_array);
...
```

Example: Reading CLOB Data

The following example uses the `setCharacterStream()` method to read `CLOB` data into a `Unicode` character stream. It then reads the character stream into a character array (returning the number of characters read, as well).

```
// Read CLOB data from CLOB locator into Reader char stream.
Reader char_stream = my_clob.setCharacterStream(1L);
char [] char_array = new char [10];
int chars_read = char_stream.read (char_array, 0, 10);
...
```

The next example uses the `setAsciiStream()` method of the `oracle.sql.CLOB` class to read CLOB data into an ASCII character stream. It then reads the ASCII stream into a byte array (returning the number of bytes read, as well).

```
// Read CLOB data from CLOB locator into Input ASCII character stream
Inputstream asciiChar_stream = my_clob.setAsciiStream(1L);
byte[] asciiChar_array = new byte[10];
int asciiChar_read = asciiChar_stream.read(asciiChar_array,0,10);
```

Example: Writing BLOB Data

Use the `setBinaryOutputStream()` method of an `oracle.sql.BLOB` object to write BLOB data.

The following example reads a vector of data into a byte array, then uses the `setBinaryOutputStream()` method to write an array of character data to a BLOB.

```
java.io.OutputStream outstream;

// read data into a byte array
byte[] data = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9};

// write the array of binary data to a BLOB
outstream = ((BLOB)my_blob).setBinaryOutputStream(1L);
outstream.write(data);
...
```

Example: Writing CLOB Data

Use the `setCharacterStream()` method or the `setAsciiStream()` method to write data to a CLOB. The `setCharacterStream()` method returns a `Unicode` output stream; the `setAsciiStream()` method returns an ASCII output stream.

The following example reads a vector of data into a character array, then uses the `setCharacterStream()` method to write the array of character data to a CLOB. The

setCharacterStream() method returns a java.io.Writer instance in an oracle.sql.CLOB object, not a java.sql.Clob object.

```
java.io.Writer writer;

// read data into a character array
char[] data = {'0','1','2','3','4','5','6','7','8','9'};

// write the array of character data to a CLOB
writer = ((CLOB)my_clob).setCharacterStream();
writer.write(data);
writer.flush();
writer.close();
...
```

The next example reads a vector of data into a byte array, then uses the setAsciiStream() method to write the array of ASCII data to a CLOB. Because setAsciiStream() returns an ASCII output stream, you must cast the output to a oracle.sql.CLOB datatype.

```
java.io.OutputStream out;

// read data into a byte array
byte[] data = {'0','1','2','3','4','5','6','7','8','9'};

// write the array of ascii data to a CLOB
out = ((CLOB)clob).setAsciiStream();
out.write(data);
out.flush();
out.close();
```

Creating and Populating a BLOB or CLOB Column

Create and populate a BLOB or CLOB column in a table by using SQL statements.

> **Note:** You cannot construct a new BLOB or CLOB locator in your application with a Java new statement. You must create the locator through a SQL operation, and then select it into your application or with the createTemporary() or empty_lob() methods.

Create a BLOB or CLOB column in a table with the SQL CREATE TABLE statement, then populate the LOB. This includes creating the LOB entry in the table, obtaining the LOB locator, creating a file handler for the data (if you are reading the data from a file), and then copying the data into the LOB.

Creating a BLOB or CLOB Column in a New Table

To create a BLOB or CLOB column in a new table, execute the SQL CREATE TABLE statement. The following example code creates a BLOB column in a new table. This example assumes that you have already created your Connection object conn and Statement object stmt:

```
String cmd = "CREATE TABLE my_blob_table (x varchar2 (30), c blob)";
stmt.execute (cmd);
```

In this example, the VARCHAR2 column designates a row number, such as 1 or 2, and the BLOB column stores the locator of the BLOB data.

Populating a BLOB or CLOB Column in a New Table

This example demonstrates how to populate a `BLOB` or `CLOB` column by reading data from a stream. These steps assume that you have already created your `Connection` object `conn` and `Statement` object `stmt`. The table `my_blob_table` is the table that was created in the previous section.

The following example writes the `GIF` file `john.gif` to a BLOB.

1. Begin by using SQL statements to create the BLOB entry in the table. Use the `empty_blob` syntax to create the BLOB locator.

   ```
   stmt.execute ("INSERT INTO my_blob_table VALUES ('row1', empty_blob())");
   ```

2. Get the BLOB locator from the table.

   ```
   BLOB blob;
   cmd = "SELECT * FROM my_blob_table WHERE X='row1'";
   ResultSet rset = stmt.executeQuery(cmd);
   rset.next();
   BLOB blob = ((OracleResultSet)rset).getBLOB(2);
   ```

3. Declare a file handler for the `john.gif` file, then print the length of the file. This value will be used later to ensure that the entire file is read into the BLOB. Next, create a `FileInputStream` object to read the contents of the `GIF` file, and an `OutputStream` object to retrieve the BLOB as a stream.

   ```
   File binaryFile = new File("john.gif");
   System.out.println("john.gif length = " + binaryFile.length());
   FileInputStream instream = new FileInputStream(binaryFile);
   OutputStream outstream = blob.setBinaryStream(1L);
   ```

4. Call `getBufferSize()` to retrieve the ideal buffer size (according to calculations by the JDBC driver) to use in writing to the BLOB, then create the `buffer` byte array.

   ```
   int size = blob.getBufferSize();
   byte[] buffer = new byte[size];
   int length = -1;
   ```

5. Use the `read()` method to read the `GIF` file to the byte array `buffer`, then use the `write()` method to write it to the BLOB. When you finish, close the input and output streams.

   ```
   while ((length = instream.read(buffer)) != -1)
      outstream.write(buffer, 0, length);
   instream.close();
   outstream.close();
   ```

Once your data is in the BLOB or CLOB, you can manipulate the data. This is described in the next section, "Accessing and Manipulating BLOB and CLOB Data".

Accessing and Manipulating BLOB and CLOB Data

Once you have your BLOB or CLOB locator in a table, you can access and manipulate the data to which it points. To access and manipulate the data, you first must select their locators from a result set or from a callable statement. "Getting and Passing BLOB and CLOB Locators" on page 14-2 describes these techniques in detail.

After you select the locators, you can retrieve the BLOB or CLOB data. You will usually want to cast the result set to the `OracleResultSet` datatype so that you can

retrieve the data in `oracle.sql.*` format. After retrieving the BLOB or CLOB data, you can manipulate it however you want.

This example is a continuation of the example in the previous section. It uses the SQL `SELECT` statement to select the BLOB locator from the table `my_blob_table` into a result set. The result of the data manipulation is to print the length of the BLOB in bytes.

```
// Select the blob - what we are really doing here
// is getting the blob locator into a result set
BLOB blob;
cmd = "SELECT *  FROM my_blob_table";
ResultSet rset = stmt.executeQuery (cmd);

// Get the blob data - cast to OracleResult set to
// retrieve the data in oracle.sql format
String index = ((OracleResultSet)rset).getString(1);
blob = ((OracleResultSet)rset).getBLOB(2);

// get the length of the blob
int length = blob.length();

// print the length of the blob
System.out.println("blob length" + length);

// read the blob into a byte array
// then print the blob from the array
byte bytes[] = blob.getBytes(1, length);
blob.printBytes(bytes, length);
```

Additional BLOB and CLOB Features

In addition to what has already been discussed in this chapter, the `oracle.sql.BLOB` and `oracle.sql.CLOB` classes have a number of methods for further functionality.

> **Note:** The `oracle.sql.CLOB` class supports all the character sets that the Oracle data server supports for CLOB types.

Additional BLOB Methods

The `oracle.sql.BLOB` class includes the following methods:

- `close()`: Closes the BLOB associated with the locator. (See "Using Open and Close With LOBs" on page 14-14 for more information.)
- `freeTemporary()`: Frees the storage used by a temporary BLOB. (See "Working With Temporary LOBs" on page 14-13 for more information.)
- `setBinaryStream(long)`: Returns the BLOB data for this Blob instance as a stream of bytes beginning at the position in the BLOB specified in the argument.
- `getBufferSize()`: Returns the ideal buffer size, according to calculations by the JDBC driver, to use in reading and writing BLOB data. This value is a multiple of the chunk size (see `getChunkSize()` below) and is close to 32K.
- `getBytes()`: Reads from the BLOB data, starting at a specified point, into a supplied buffer.

- `getChunkSize()`: Returns the Oracle chunking size, which can be specified by the database administrator when the LOB column is first created. This value, in Oracle blocks, determines the size of the chunks of data read or written by the LOB data layer in accessing or modifying the BLOB value. Part of each chunk stores system-related information, and the rest stores LOB data. Performance is enhanced if read and write requests use some multiple of the chunk size.
- `isOpen()`: Returns `true` if the BLOB was opened by calling the `open()` method; otherwise, it returns `false`. (See "Using Open and Close With LOBs" on page 14-14 for more information.)
- `isTemporary()`: Returns true if the BLOB is a temporary BLOB. (See "Working With Temporary LOBs" on page 14-13 for more information.)
- `length()`: Returns the length of the BLOB in bytes.
- `open()`: Opens the BLOB associated with the locator. (See "Using Open and Close With LOBs" on page 14-14 for more information.)
- `open(int)`: Opens the BLOB associated with the locator in the mode specified by the argument. (See "Using Open and Close With LOBs" on page 14-14 for more information.)
- `position()`: Determines the byte position in the BLOB where a given pattern begins.
- `setBytes()`: Writes BLOB data, starting at a specified point, from a supplied buffer.
- `truncate(long)`: Trims the value of the BLOB to the length specified by the argument.

Additional CLOB Methods

The `oracle.sql.CLOB` class includes the following methods:

- `close()`: Closes the CLOB associated with the locator. (See "Using Open and Close With LOBs" on page 14-14 for more information.)
- `freeTemporary()`: Frees the storage used by a temporary CLOB. (See "Working With Temporary LOBs" on page 14-13 for more information.)
- `setAsciiStream(long)`: Returns a `java.io.OutputStream` object to write data to the CLOB as a stream. The data is written beginning at the position in the CLOB specified by the argument.
- `getAsciiStream()`: Returns the CLOB value designated by the `Clob` object as a stream of ASCII bytes.
- `getAsciiStream(long)`: Returns the CLOB value designated by the CLOB object as a stream of ASCII bytes, beginning at the position in the CLOB specified by the argument.
- `getBufferSize()`: Returns the ideal buffer size, according to calculations by the JDBC driver, to use in reading and writing CLOB data. This value is a multiple of the chunk size (see `getChunkSize()` below) and is close to 32K.
- `setCharacterStream(long)`: Returns a `java.io.Writer` object to write data to the CLOB as a stream. The data is written beginning at the position in the CLOB specified by the argument.
- `getCharacterStream()`: Returns the CLOB data as a stream of `Unicode` characters.

- `getCharacterStream(long)`: Returns the CLOB data as a stream of Unicode characters beginning at the position in the CLOB specified by the argument.
- `getChars()`: Retrieves characters from a specified point in the CLOB data into a character array.
- `getChunkSize()`: Returns the Oracle chunking size, which can be specified by the database administrator when the LOB column is first created. This value, in Oracle blocks, determines the size of the chunks of data read or written by the LOB data layer in accessing or modifying the CLOB value. Part of each chunk stores system-related information and the rest stores LOB data. Performance is enhanced if you make read and write requests using some multiple of the chunk size.
- `isOpen()`: Returns `true` if the CLOB was opened by calling the open() method; otherwise, it returns `false`. (See "Using Open and Close With LOBs" on page 14-14 for more information.)
- `isTemporary()`: Returns true if and only if the CLOB is a temporary CLOB. (See "Working With Temporary LOBs" on page 14-13 for more information.)
- `length()`: Returns the length of the CLOB in characters.
- `open()`: Opens the CLOB associated with the locator. (See "Using Open and Close With LOBs" on page 14-14 for more information.)
- `open(int)`: Opens the CLOB associated with the locator in the mode specified by the argument. (See "Using Open and Close With LOBs" on page 14-14 for more information.)
- `position()`: Determines the character position in the CLOB at which a given substring begins.
- `putChars()`: Writes characters from a character array to a specified point in the CLOB data.
- `getSubString()`: Retrieves a substring from a specified point in the CLOB data.
- `setString(long pos, String str)`: Writes a string to a specified point in the CLOB data.
- `truncate(long)`: Trims the value of the CLOB to the length specified by the argument.

Creating Empty LOBs

Before writing data to an internal LOB, you must make sure the LOB column/attribute is not `null`: it must contain a locator. You can accomplish this by initializing the internal LOB as an empty LOB in an `INSERT` or `UPDATE` statement, using the `empty_lob()` method defined in the `oracle.sql.BLOB` and `oracle.sql.CLOB` classes:

- `public static BLOB empty_lob() throws SQLException`
- `public static CLOB empty_lob() throws SQLException`

A JDBC driver creates an empty LOB instance without making database round trips. You can use empty LOBs in the following:

- setXXX() methods of the OraclePreparedStatement class
- updateXXX() methods of updatable result sets
- attributes of STRUCT objects
- elements of ARRAY objects

> **Note:** Because an empty_lob() method creates a special marker that does not contain a locator, a JDBC application cannot read or write to it. The JDBC driver throws the exception ORA-17098 Invalid empty LOB operation if a JDBC application attempts to read or write to an empty LOB before it is stored in the database.

Shortcuts For Inserting and Retrieving CLOB Data

You often use a CLOB column to store character data which may be larger than the size permitted by a VARCHAR column, if and only it is known that the actual data stored is within the limits which can be bound with setString().

```
CREATE TABLE MY_CLOB_TAB( C CLOB )
PreparedStatement pstmt = conn.prepareStatement(
  "INSERT INTO MY_CLOB_TAB VALUES ( ? )" );
pstmt.setString( 1, "a string that is less than 32765 bytes" );

pstmt.execute();
```

The string data is transferred to the database and automatically transformed into a CLOB which is inserted into the column.

In 10*g* Release 1 (10.1) an additional method, pstmt(), is added to OraclePreparedStatement.

```
OraclePreparedStatement pstmt = (OraclePreparedStatement)(conn.pstmt(
    "INSERT INTO MY_CLOB_TAB VALUES ( ? )" ));

pstmt.setStringForClob( 1, "any Java string" );

pstmt.execute();
```

In addition, there is a connection property SetBigStringUseClob. Setting this property forces PreparedStatement.setString() method to use setStringForClob() if the data is larger than 32765 bytes. Please note that using this method with VARCHAR and LONG columns may cause large data to be truncated silently, or cause other errors differing from the normal behavior of setString().

You can use getString() to read a CLOB column.

For both of these operations, the only limit on the size of the string is the limit imposed by Java Language itself, which is that the length must be a positive Java int. Note, however, that if the data is extremely large it is may not be wise to handle it this way. Please read the information provided by your Java Virtual Machine vendor about the impact of very large data elements on memory management, and consider using the stream interfaces instead.

CLOB and BLOB data may also be read and written using the same streaming mechanism as for LONG and LONG RAW data. To read, use defineColumnType(nn, Types.LONGVARCHAR) or defineColumnType(nn, Types.LONGVARBINARY) on the column; this produces a direct stream on the data as

if it were a LONG or LONG RAW column. For input in a `PreparedStatement`, you may use `setBinaryStream()`, `setCharacterStream()`, or `setAsciiStream()` for a parameter which is a BLOB or CLOB. These methods will use the stream interface to create a LOB in the database from the data from the stream. Both of these techniques reduce database round trips and may result in improved performance in some cases. See the Javadoc on stream data for the significant restrictions which apply.

Working With Temporary LOBs

You can use temporary LOBs to store transient data. The data is stored in temporary table space rather than regular table space. You should free temporary LOBs after you no longer need them. If you do not, the space the LOB consumes in temporary table space will not be reclaimed

You can insert temporary LOBs into a table. When you do this, a permanent copy of the LOB is created and stored. This is an alternative to the procedure described in "Creating and Populating a BLOB or CLOB Column" on page 14-7. Inserting a temporary LOB may be preferable for some situations; remember that the data is initially stored in the temporary table space on the server and then moved into permanent storage.

You create a temporary LOB with the static method `createTemporary(Connection, boolean, int)`. This method is defined in both the `oracle.sql.BLOB` and `oracle.sql.CLOB` classes. You free a temporary LOB with the `freeTemporary()` method.

```
public static BLOB createTemporary(Connection conn, boolean isCached, int
duration);
public static CLOB createTemporary(Connection conn, boolean isCached, int
duration);
```

The duration must be either `DURATION_SESSION` or `DURATION_CALL` as defined in the `oracle.sql.BLOB` or `oracle.sql.CLOB` class. In client applications `DURATION_SESSION` is appropriate. In Java stored procedures you can use either `DURATION_SESSION` or `DURATION_CALL`, which ever is appropriate.

You can test whether a LOB is temporary by calling the `isTemporary()` method. If the LOB was created by calling the `createTemporary()` method, the `isTemporary()` method returns `true`; otherwise, it returns `false`.

You can free a temporary LOB by calling the `freeTemporary()` method. Free any temporary LOBs before ending the session or call. Otherwise, the storage used by the temporary LOB will not be reclaimed.

Note: Failure to free a temporary LOB will result in the storage used by that LOB being unavailable. Frequent failure to free temporary LOBs will result in filling up temporary table space with unavailable LOB storage.

Creating Temporary NCLOBs

You create temporary NCLOBs using a variant of the `createTemporary()` method.

The syntax is:

```
CLOB.createTemporary (Connection conn, boolean cache, int duration,
  short form);
```

The `form` argument specifies whether the created LOB is a CLOB or an NCLOB. If `form` equals `oracle.jdbc.OraclePreparedStatement.FORM_NCHAR`, then the method creates an NCLOB; if `form` equals `oracle.jdbc.OraclePreparedStatement.FORM_CHAR`, the method creates a CLOB.

Using Open and Close With LOBs

You do not have to open and close your LOBs. You might choose to open and close them for performance reasons.

If you do not wrap LOB operations inside an Open/Close call operation: Each modification to the LOB will implicitly open and close the LOB thereby firing any triggers on an domain index. Note that in this case, any domain indexes on the LOB will become updated as soon as LOB modifications are made. Therefore, domain LOB indexes are always valid and may be used at any time.

If you wrap your LOB operations inside the Open/Close operation, triggers will not be fired for each LOB modification. Instead, the trigger on domain indexes will be fired at the Close call. For example, you might design your application so that domain indexes are not be updated until you call the `close()` method. However, this means that any domain indexes on the LOB will not be valid in-between the Open/Close calls.

You open a LOB by calling the `open()` or `open(int)` method. You may then read and write the LOB without any triggers associated with that LOB firing. When you are done accessing the LOB, close the LOB by calling the `close()` method. When you close the LOB, any triggers associated with the LOB will fire. You can see if a LOB is open or closed by calling the `isOpen()` method. If you open the LOB by calling the `open(int)` method, the value of the argument must be either `MODE_READONLY` or `MODE_READWRITE`, as defined in the `oracle.sql.BLOB` and `oracle.sql.CLOB` classes. If you open the LOB with `MODE_READONLY`, any attempt to write to the LOB will result in a SQL exception.

Note: An error occurs if you commit the transaction before closing all opened LOBs that were opened by the transaction. The openness of the open LOBs is discarded, but the transaction is successfully committed. Hence, all the changes made to the LOB and non-LOB data in the transaction are committed but the triggers for domain indexing are not fixed.

Working with BFILEs

This section describes how to read and write data to and from external binary files (BFILEs), using file locators.

Getting and Passing BFILE Locators

Getter and setter methods are available for retrieving or passing BFILE locators from or to the database.

Retrieving BFILE Locators

Given a standard JDBC result set or callable statement object that includes BFILE locators, you can access the locators by using the standard result set `getObject()` method. This method returns an `oracle.sql.BFILE` object.

You can also access the locators by casting your result set to `OracleResultSet` or your callable statement to `OracleCallableStatement` and using the `getOracleObject()` or `getBFILE()` method.

Notes:

- In the `OracleResultSet` and `OracleCallableStatement` classes, `getBFILE()` and `getBfile()` both return `oracle.sql.BFILE`. There is no `java.sql` interface for BFILEs.
- If using `getObject()` or `getOracleObject()`, remember to cast the output, as necessary. For more information, see "Datatypes For Returned Objects from getObject and getXXX" on page 11-8.

Example: Getting a BFILE locator from a Result Set Assume that the database has a table called `bfile_table` with a single column for the BFILE locator `bfile_col`. This example assumes that you have already created your `Statement` object `stmt`.

Select the BFILE locator into a standard result set. If you cast the result set to an `OracleResultSet`, you can use `getBFILE()` to get the BFILE locator:

```
// Select the BFILE locator into a result set
ResultSet rs = stmt.executeQuery("SELECT bfile_col FROM bfile_table");
while (rs.next())
{
   oracle.sql.BFILE my_bfile = ((OracleResultSet)rs).getBFILE(1);
}
```

Note that as an alternative, you can use `getObject()` to return the BFILE locator. In this case, because `getObject()` returns a `java.lang.Object`, cast the results to `BFILE`. For example:

```
oracle.sql.BFILE my_bfile = (BFILE)rs.getObject(1);
```

Example: Getting a BFILE Locator from a Callable Statement Assume you have an `OracleCallableStatement` object `ocs` that calls a function `func` that has a `BFILE` output parameter. The following code example sets up the callable statement, registers the output parameter as `OracleTypes.BFILE`, executes the statement, and retrieves the BFILE locator:

```
OracleCallableStatement ocs =
   (OracleCallableStatement)conn.prepareCall("{? = call func()}");
ocs.registerOutParameter(1, OracleTypes.BFILE);
ocs.execute();
oracle.sql.BFILE bfile = ocs.getBFILE(1);
```

Passing BFILE Locators

To pass a BFILE locator to a prepared statement or callable statement (to update a BFILE locator, for example), you can do one of the following:

- Use the standard `setObject()` method.

or:

- Cast the statement to `OraclePreparedStatement` or `OracleCallableStatement`, and use the `setOracleObject()` or `setBFILE()` method.

These methods take the parameter index and an `oracle.sql.BFILE` object as input.

Example: Passing a BFILE Locator to a Prepared Statement Assume you want to insert a BFILE locator into a table, and you have an `OraclePreparedStatement` object `ops` to insert data into a table. The first column is a string (to designate a row number), the second column is a BFILE, and you have a valid `oracle.sql.BFILE` object (`bfile`). Write the BFILE to the database as follows:

```
OraclePreparedStatement ops = (OraclePreparedStatement)conn.prepareStatement
                            ("INSERT INTO my_bfile_table VALUES (?,?)");
ops.setString(1,"one");
ops.setBFILE(2, bfile);
ops.execute();
```

Example: Passing a BFILE Locator to a Callable Statement Passing a BFILE locator to a callable statement is similar to passing it to a prepared statement. In this case, the BFILE locator is passed to the `myGetFileLength()` procedure, which returns the BFILE length as a numeric value.

```
OracleCallableStatement cstmt = (OracleCallableStatement)conn.prepareCall
                              ("begin ? := myGetFileLength (?); end;");
try
{
   cstmt.registerOutParameter (1, Types.NUMERIC);
   cstmt.setBFILE (2, bfile);
   cstmt.execute ();
   return cstmt.getLong (1);
}
```

Reading BFILE Data

To read BFILE data, you must first get the BFILE locator. You can get the locator from either a callable statement or a result set. "Getting and Passing BFILE Locators" on page 14-15 describes this.

Once you obtain the locator, you can invoke a number of methods on the BFILE without opening it. For example, you can use the `oracle.sql.BFILE` methods `fileExists()` and `isFileOpen()` to determine whether the BFILE exists and if it is open. If you want to read and manipulate the data, however, you must open and close the BFILE, as follows:

- Use the `openFile()` method of the `oracle.sql.BFILE` class to open a BFILE.
- When you are done, use the `closeFile()` method of the `BFILE` class.

BFILE data is materialized as a Java stream. To read from a BFILE, use the `getBinaryStream()` method of an `oracle.sql.BFILE` object to retrieve the entire file as an input stream. This returns a `java.io.InputStream` object.

As with any `InputStream` object, use one of the overloaded `read()` methods to read the file data, and use the `close()` method when you finish.

Notes:

- BFILEs are read-only. You cannot insert data or otherwise write to a BFILE.
- You cannot use JDBC to create a new BFILE. They are created only externally.

Example: Reading BFILE Data

The following example uses the `getBinaryStream()` method of an `oracle.sql.BFILE` object to read BFILE data into a byte stream and then read the byte stream into a byte array. The example assumes that the BFILE has already been opened.

```
// Read BFILE data from a BFILE locator
Inputstream in = bfile.getBinaryStream();
byte[] byte_array = new byte{10};
int byte_read = in.read(byte_array);
```

Creating and Populating a BFILE Column

This section discusses how to create a `BFILE` column in a table with SQL operations and specify the location where the BFILE resides. The examples below assume that you have already created your `Connection` object `conn` and `Statement` object `stmt`.

Creating a BFILE Column in a New Table

To work with BFILE data, create a `BFILE` column in a table, and specify the location of the BFILE. To specify the location of the BFILE, use the SQL `CREATE DIRECTORY...AS` statement to specify an alias for the directory where the BFILE resides. Then execute the statement. In this example, the directory alias is `test_dir`, and the BFILE resides in the `/home/work` directory.

```
String cmd;
cmd = "CREATE DIRECTORY test_dir AS '/home/work'";
stmt.execute (cmd);
```

Use the SQL `CREATE TABLE` statement to create a table containing a `BFILE` column, then execute the statement. In this example, the name of the table is `my_bfile_table`.

```
// Create a table containing a BFILE field
cmd = "CREATE TABLE my_bfile_table (x varchar2 (30), b bfile)";
stmt.execute (cmd);
```

In this example, the VARCHAR2 column designates a row number, and the BFILE column stores the locator of the BFILE data.

Populating a BFILE Column

Use the SQL INSERT INTO...VALUES statement to populate the VARCHAR2 and BFILE fields, then execute the statement. The BFILE column is populated with the locator to the BFILE data. To populate the BFILE column, use the bfilename function to specify the directory alias and the name of the BFILE file.

```
cmd ="INSERT INTO my_bfile_table VALUES ('one', bfilename(test_dir,
                                         'file1.data'))";
stmt.execute (cmd);
cmd ="INSERT INTO my_bfile_table VALUES ('two', bfilename(test_dir,
                                         'jdbcTest.data'))";
stmt.execute (cmd);
```

In this example, the name of the directory alias is test_dir. The locator of the BFILE file1.data is loaded into the BFILE column on row one, and the locator of the BFILE jdbcTest.data is loaded into the bfile column on row two.

As an alternative, you might want to create the row for the row number and BFILE locator now, but wait until later to insert the locator. In this case, insert the row number into the table, and null as a place holder for the BFILE locator.

```
cmd ="INSERT INTO my_bfile_table VALUES ('three', null)";
stmt.execute(cmd);
```

Here, three is inserted into the row number column, and null is inserted as the place holder. Later in your program, insert the BFILE locator into the table by using a prepared statement.

First get a valid BFILE locator into the bfile object:

```
rs = stmt.executeQuery("SELECT b FROM my_bfile_table WHERE x='two'");
rs.next();
oracle.sql.BFILE bfile = ((OracleResultSet)rs).getBFILE(1);
```

Then, create your prepared statement. Note that because this example uses the setBFILE() method to identify the BFILE, the prepared statement must be cast to an OraclePreparedStatement:

```
OraclePreparedStatement ops = (OraclePreparedStatement)conn.prepareStatement
                     (UPDATE my_bfile_table SET b=? WHERE x = 'three');
ops.setBFILE(1, bfile);
ops.execute();
```

Now row two and row three contain the same BFILE.

Once you have the BFILE locators available in a table, you can access and manipulate the BFILE data. The next section, "Accessing and Manipulating BFILE Data", describes this.

Accessing and Manipulating BFILE Data

Once you have the BFILE locator in a table, you can access and manipulate the data to which it points. To access and manipulate the data, you must first select its locator from a result set or a callable statement.

The following code continues the example from "Populating a BFILE Column" on page 14-18, getting the locator of the BFILE from row `two` of a table into a result set. The result set is cast to an `OracleResultSet` so that `oracle.sql.*` methods can be used on it. Several of the methods applied to the BFILE, such as `getDirAlias()` and `getName()`, do not require you to open the BFILE. Methods that manipulate the BFILE data, such as reading, getting the length, and displaying, *do* require you to open the BFILE.

When you finish manipulating the BFILE data, you must close the BFILE.

```
// select the bfile locator
cmd = "SELECT *  FROM my_bfile_table WHERE x = 'two'";
rset = stmt.executeQuery (cmd);

if (rset.next ())
    BFILE bfile = ((OracleResultSet)rset).getBFILE (2);

// for these methods, you do not have to open the bfile
println("getDirAlias() = " + bfile.getDirAlias());
println("getName() = " + bfile.getName());
println("fileExists() = " + bfile.fileExists());
println("isFileOpen() = " + bfile.isFileOpen());

// now open the bfile to get the data
bfile.openFile();

// get the BFILE data as a binary stream
InputStream in = bfile.getBinaryStream();
int length ;

// read the bfile data in 6-byte chunks
byte[] buf = new byte[6];

while ((length = in.read(buf)) != -1)
{
    // append and display the bfile data in 6-byte chunks
   StringBuffer sb = new StringBuffer(length);
   for (int i=0; i<length; i++)
      sb.append( (char)buf[i] );
   System.out.println(sb.toString());
}

// we are done working with the input stream. Close it.
in.close();

// we are done working with the BFILE. Close it.
bfile.closeFile();
```

Additional BFILE Features

In addition to the features already discussed in this chapter, the `oracle.sql.BFILE` class has a number of methods for further functionality, including the following:

- `openFile()`: Opens the external file for read-only access.
- `closeFile()`: Closes the external file.
- `getBinaryStream()`: Returns the contents of the external file as a stream of bytes.
- `getBinaryStream(long)`: Returns the contents of the external file as a stream of bytes beginning at the position in the external file specified by the argument.
- `getBytes()`: Reads from the external file, starting at a specified point, into a supplied buffer.
- `getName()`: Gets the name of the external file.
- `getDirAlias()`: Gets the directory alias of the external file.
- `length()`: Returns the length of the BFILE in bytes.
- `position()`: Determines the byte position at which the given byte pattern begins.
- `isFileOpen()`: Determines whether the BFILE is open (for read-only access).

15

Using Oracle Object References

This chapter describes Oracle extensions to standard JDBC that let you access and manipulate object references. The following topics are discussed:

Oracle Extensions for Object References

Oracle supports the use of references (pointers) to Oracle database objects. Oracle JDBC provides support for object references as:

- columns in a SELECT-list
- `IN` or `OUT` bind variables
- attributes in an Oracle object
- elements in a collection (array) type object

In SQL, an object reference (`REF`) is strongly typed. For example, a reference to an `EMPLOYEE` object would be defined as an `EMPLOYEE REF`, not just a `REF`.

When you select an object reference in Oracle JDBC, be aware that you are retrieving only a pointer to an object, not the object itself. You have the choice of materializing the reference as a weakly typed `oracle.sql.REF` instance (or a `java.sql.Ref` instance for portability), or materializing it as an instance of a custom Java class that you have created in advance, which is strongly typed. Custom Java classes used for object references are referred to as *custom reference classes* in this manual and must implement the `oracle.sql.ORAData` interface.

The `oracle.sql.REF` class implements the standard `java.sql.Ref` interface.

You can retrieve a `REF` instance through a result set or callable statement object, and pass an updated `REF` instance back to the database through a prepared statement or callable statement object. The `REF` class includes functionality to get and set underlying object attribute values, and get the SQL base type name of the underlying object (for example, `EMPLOYEE`).

Custom reference classes include this same functionality, as well as having the advantage of being strongly typed. This can help you find coding errors during compilation that might not otherwise be discovered until runtime.

For more information about custom reference classes, see "Custom Reference Classes with JPublisher" on page 15-5.

Notes:

- If you are using the `oracle.sql.ORAData` interface for custom object classes, you will presumably use `ORAData` for corresponding custom reference classes as well. If you are using the standard `java.sql.SQLData` interface for custom object classes, however, you can only use weak Java types for references (`java.sql.Ref` or `oracle.sql.REF`). The `SQLData` interface is for mapping SQL object types only.
- You cannot create `REF` objects in your JDBC application; you can only retrieve existing `REF` objects from the database.
- You cannot have a reference to an array, even though arrays, like objects, are structured types.

Overview of Object Reference Functionality

To access and update object data through an object reference, you must obtain the reference instance through a result set or callable statement and then pass it back as a bind variable in a prepared statement or callable statement. It is the reference instance that contains the functionality to access and update object attributes.

This section summarizes the following:

- statement and result set getter and setter methods for passing `REF` instances from and to the database
- `REF` class functionality to get and set object attributes

Remember that you can use custom reference classes instead of the `ARRAY` class. See "Custom Reference Classes with JPublisher" on page 15-5.

Object Reference Getter and Setter Methods

Use the following result set, callable statement, and prepared statement methods to retrieve and pass object references. Code examples are provided later in the chapter.

Result Set and Callable Statement Getter Methods

The `OracleResultSet` and `OracleCallableStatement` classes support `getREF()` and `getRef()` methods to retrieve `REF` objects as output parameters—either as `oracle.sql.REF` instances or `java.sql.Ref` instances. You can also use the `getObject()` method. These methods take as input a `String` column name or `int` column index.

Prepared and Callable Statement Setter Methods

The `OraclePreparedStatement` and `OracleCallableStatement` classes support `setREF()` and `setRef()` methods to take `REF` objects as bind variables and pass them to the database. You can also use the `setObject()` method. These methods take as input a `String` parameter name or `int` parameter index as well as, respectively, an `oracle.sql.REF` instance or a `java.sql.Ref` instance.

Key REF Class Methods

Use the following `oracle.sql.REF` class methods to retrieve the SQL object type name and retrieve and pass the underlying object data.

- `getBaseTypeName()`: Retrieves the fully-qualified SQL structured type name of the referenced object (for example, `EMPLOYEE`).

  This is a standard method specified by the `java.sql.Ref` interface.

- `getValue()`: Retrieves the referenced object from the database, allowing you to access its attribute values. It optionally takes a type map object, or else you can use the default type map of the database connection object.

  This method is an Oracle extension.

- `setValue()`: Sets the referenced object in the database, allowing you to update its attribute values. It takes an instance of the object type as input (either a `STRUCT` instance or an instance of a custom object class).

  This method is an Oracle extension.

Retrieving and Passing an Object Reference

This section discusses JDBC functionality for retrieving and passing object references.

Retrieving an Object Reference from a Result Set

To demonstrate how to retrieve object references, the following example first defines an Oracle object type `ADDRESS`, which is then referenced in the `PEOPLE` table:

```
create type ADDRESS as object
   (street_name     VARCHAR2(30),
    house_no        NUMBER);

create table PEOPLE
    (col1 VARCHAR2(30),
     col2 NUMBER,
     col3 REF ADDRESS);
```

The `ADDRESS` object type has two attributes: a street name and a house number. The `PEOPLE` table has three columns: a column for character data, a column for numeric data, and a column containing a reference to an `ADDRESS` object.

To retrieve an object reference, follow these general steps:

1. Use a standard SQL `SELECT` statement to retrieve the reference from a database table `REF` column.
2. Use `getREF()` to get the address reference from the result set into a `REF` object.
3. Let `Address` be the Java custom class corresponding to the SQL object type `ADDRESS`.
4. Add the correspondence between the Java class `Address` and the SQL type `ADDRESS` to your type map.
5. Use the `getValue()` method to retrieve the contents of the `Address` reference. Cast the output to a Java `Address` object.

Here is the code for these steps (other than adding `Address` to the type map), where `stmt` is a previously defined statement object. The `PEOPLE` database table is defined earlier in this section:

```
ResultSet rs = stmt.executeQuery("SELECT col3 FROM PEOPLE");
while (rs.next())
{
   REF ref = ((OracleResultSet)rs).getREF(1);
   Address a = (Address)
ref.getValue();
}
```

As with other SQL types, you could retrieve the reference with the `getObject()` method of your result set. Note that this would require you to cast the output. For example:

```
REF ref = (REF)rs.getObject(1);
```

There are no performance advantages in using `getObject()` instead of `getREF();` however, using `getREF()` allows you to avoid casting the output.

Retrieving an Object Reference from a Callable Statement

To retrieve an object reference as an `OUT` parameter in PL/SQL blocks, you must register the bind type for your `OUT` parameter.

1. Cast your callable statement to an `OracleCallableStatement`:

   ```
   OracleCallableStatement ocs =
      (OracleCallableStatement)conn.prepareCall("{? = call func()}");
   ```

2. Register the `OUT` parameter with this form of the `registerOutParameter()` method:

   ```
   ocs.registerOutParameter
               (int param_index, int sql_type, String sql_type_name);
   ```

   Where *`param_index`* is the parameter index and *`sql_type`* is the SQL typecode (in this case, `OracleTypes.REF`). The *`sql_type_name`* is the name of the structured object type that this reference is used for. For example, if the `OUT` parameter is a reference to an `ADDRESS` object (as in "Retrieving and Passing an Object Reference" on page 15-3), then `ADDRESS` is the *`sql_type_name`* that should be passed in.

3. Execute the call:

   ```
   ocs.execute();
   ```

Passing an Object Reference to a Prepared Statement

Pass an object reference to a prepared statement in the same way as you would pass any other SQL type. Use either the `setObject()` method or the `setREF()` method of a prepared statement object.

Continuing the example in "Retrieving and Passing an Object Reference" on page 15-3, use a prepared statement to update an address reference based on `ROWID`, as follows:

```
PreparedStatement pstmt =
   conn.prepareStatement ("update PEOPLE set ADDR_REF = ? where ROWID = ?");
((OraclePreparedStatement)pstmt).setREF (1, addr_ref);
((OraclePreparedStatement)pstmt).setROWID (2, rowid);
```

Accessing and Updating Object Values through an Object Reference

You can use the REF object setValue() method to update the value of an object in the database through an object reference. To do this, you must first retrieve the reference to the database object and create a Java object (if one does not already exist) that corresponds to the database object.

For example, you can use the code in the section "Retrieving and Passing an Object Reference" on page 15-3 to retrieve the reference to a database ADDRESS object:

```
ResultSet rs = stmt.executeQuery("SELECT col3 FROM PEOPLE");
if (rs.next())
{
   REF ref = rs.getREF(1);
   Address a = (Address)
ref.getValue();
}
```

Then, you can create a Java Address object (this example omits the content for the constructor of the Address class) that corresponds to the database ADDRESS object. Use the setValue() method of the REF class to set the value of the database object:

```
Address addr = new Address(...);
ref.setValue(addr);
```

Here, the setValue() method updates the database ADDRESS object immediately.

Custom Reference Classes with JPublisher

This chapter primarily describes the functionality of the oracle.sql.REF class, but it is also possible to access Oracle object references through custom Java classes or, more specifically, *custom reference classes*.

Custom reference classes offer all the functionality described earlier in this chapter, as well as the advantage of being strongly typed. A custom reference class must satisfy three requirements:

- It must implement the oracle.sql.ORAData interface described under "Creating and Using Custom Object Classes for Oracle Objects" on page 13-7. Note that the standard JDBC SQLData interface, which is an alternative for custom object classes, is not intended for custom reference classes.
- It, or a companion class, must implement the oracle.sql.ORADataFactory interface, for creating instances of the custom reference class.
- It must provide a way to refer to the object data. JPublisher accomplishes this by using an oracle.sql.REF attribute.

You can create custom reference classes yourself, but the most convenient way to produce them is through the Oracle JPublisher utility. If you use JPublisher to generate a custom object class to map to an Oracle object, and you specify that JPublisher use a ORAData implementation, then JPublisher will also generate a custom reference class that implements ORAData and ORADataFactory and includes an oracle.sql.REF attribute. (The ORAData implementation will be used if JPublisher's -usertypes mapping option is set to oracle, which is the default.)

Custom reference classes are strongly typed. For example, if you define an Oracle object EMPLOYEE, then JPublisher can generate an Employee custom object class and an EmployeeRef custom reference class. Using EmployeeRef instances instead of generic oracle.sql.REF instances makes it easier to catch errors during compilation

instead of at runtime—for example, if you accidentally assign some other kind of object reference into an `EmployeeRef` variable.

Be aware that the standard `SQLData` interface supports only SQL object mappings. For this reason, if you instruct JPublisher to implement the standard `SQLData` interface in creating a custom object class, then JPublisher will *not* generate a custom reference class. In this case your only option is to use standard `java.sql.Ref` instances (or `oracle.sql.REF` instances) to map to your object references. (Specifying the `SQLData` implementation is accomplished by setting JPublisher's UDT attributes mapping option to `jdbc`.)

For more information about JPublisher, see "Using JPublisher to Create Custom Object Classes" on page 13-32, or refer to the *Oracle Database JPublisher User's Guide.*

16

Working with Oracle Collections

This chapter describes Oracle extensions to standard JDBC that let you access and manipulate Oracle collections, which map to Java arrays, and their data. The following topics are discussed:

Oracle Extensions for Collections (Arrays)

An Oracle *collection*—either a variable array (VARRAY) or a nested table in the database—maps to an array in Java. JDBC 2.0 arrays are used to materialize Oracle collections in Java. The terms "collection" and "array" are sometimes used interchangeably, although "collection" is more appropriate on the database side, and "array" is more appropriate on the JDBC application side.

Oracle supports only *named* collections, where you specify a SQL type name to describe a type of collection.

JDBC lets you use arrays as any of the following:

- columns in a SELECT-list
- `IN` or `OUT` bind variables
- attributes in an Oracle object
- as elements of other arrays (Oracle9*i* and higher only)

The rest of this section discusses creating and materializing collections.

The remainder of the chapter describes how to access and update collection data through Java arrays.

Choices in Materializing Collections

In your application, you have the choice of materializing a collection as an instance of the `oracle.sql.ARRAY` class, which is weakly typed, or materializing it as an instance of a custom Java class that you have created in advance, which is strongly typed. Custom Java classes used for collections are referred to as *custom collection classes* in this manual. A custom collection class must implement the Oracle `oracle.sql.ORAData` interface. In addition, the custom class or a companion class must implement `oracle.sql.ORADataFactory`. (The standard `java.sql.SQLData` interface is for mapping SQL object types only.)

The `oracle.sql.ARRAY` class implements the standard `java.sql.Array` interface.

The `ARRAY` class includes functionality to retrieve the array as a whole, retrieve a subset of the array elements, and retrieve the SQL base type name of the array elements. You cannot write to the array, however, as there are no setter methods.

Custom collection classes, as with the `ARRAY` class, allow you to retrieve all or part of the array and get the SQL base type name. They also have the advantage of being strongly typed, which can help you find coding errors during compilation that might not otherwise be discovered until runtime.

Furthermore, custom collection classes produced by JPublisher offer the feature of being writable, with individually accessible elements. (This is also something you could implement in a custom collection class yourself.)

> **Note:** There is no difference in your code between accessing VARRAYs and accessing nested tables. `ARRAY` class methods can determine if they are being applied to a VARRAY or nested table, and respond by taking the appropriate actions.

For more information about custom collection classes, see "Custom Collection Classes with JPublisher" on page 16-18.

Creating Collections

This section presents background information about creating Oracle collections.

Because Oracle supports only named collections, you must declare a particular `VARRAY` type name or nested table type name. "VARRAY" and "nested table" are not types themselves, but categories of types.

A SQL type name is assigned to a collection when you create it, as in the following SQL syntax:

```
CREATE TYPE <sql_type_name> AS <datatype>;
```

A VARRAY is an array of varying size. It has an ordered set of data elements, and all the elements are of the same datatype. Each element has an index, which is a number corresponding to the element's position in the VARRAY. The number of elements in a VARRAY is the "size" of the VARRAY. You must specify a maximum size when you declare the `VARRAY` type. For example:

```
CREATE TYPE myNumType AS VARRAY(10) OF NUMBER;
```

This statement defines `myNumType` as a SQL type name that describes a VARRAY of `NUMBER` values that can contain no more than 10-elements.

A nested table is an unordered set of data elements, all of the same datatype. The database stores a nested table in a separate table which has a single column, and the type of that column is a built-in type or an object type. If the table is an object type, it can also be viewed as a multi-column table, with a column for each attribute of the object type. Create a nested table with this SQL syntax:

```
CREATE TYPE myNumList AS TABLE OF integer;
```

This statement identifies `myNumList` as a SQL type name that defines the table type used for the nested tables of the type `INTEGER`.

Creating Multi-Level Collection Types

The most common way to create a new multi-level collection type in JDBC is to pass the SQL `CREATE TYPE` statement to the `execute()` method of the `java.sql.Statement` class. The following code creates a one-level, nested table `first_level` and a two levels nested table `second_level` using the `execute()` method:

```
Connection conn = ....                              // make a database
                                                    // connection
Statement stmt = conn.createStatement();            // open a database
                                                    // cursor
stmt.execute("CREATE TYPE first_level AS TABLE OF NUMBER");  // create a nested
                                                    // table of number
stmt.execute("CREATE second_level AS TABLE OF first_level"); // create a
          // two-levels nested table
...       // other operations here
stmt.close();                                       // release the
                                                    // resource
conn.close();                                       // close the
                                                    // database connection
```

Once the multi-level collection types have been created, they can be used as both columns of a base table as well as attributes of a object type.

See the *Oracle Database Application Developer's Guide - Object-Relational Features* for the SQL syntax to create multi-level collections types and how to specify the storage tables for inner collections.

> **Note:** Multi-level collection types are available only for Oracle9*i* and higher.

Overview of Collection (Array) Functionality

You can obtain collection data in an array instance through a result set or callable statement and pass it back as a bind variable in a prepared statement or callable statement.

The `oracle.sql.ARRAY` class, which implements the standard `java.sql.Array` interface, provides the necessary functionality to access and update the data of an Oracle collection (either a VARRAY or nested table).

This section discusses the following:

- statement and result set getter and setter methods for passing collections to and from the database as Java arrays
- `ARRAY` descriptors and `ARRAY` class methods

Remember that you can use custom collection classes instead of the `ARRAY` class. See "Custom Collection Classes with JPublisher" on page 16-18.

Array Getter and Setter Methods

Use the following result set, callable statement, and prepared statement methods to retrieve and pass collections as Java arrays. Code examples are provided later in the chapter.

Result Set and Callable Statement Getter Methods

The `OracleResultSet` and `OracleCallableStatement` classes support `getARRAY()` and `getArray()` methods to retrieve `ARRAY` objects as output parameters—either as `oracle.sql.ARRAY` instances or `java.sql.Array` instances. You can also use the `getObject()` method. These methods take as input a `String` column name or `int` column index.

> **Note:** The Oracle JDBC drivers cache array and structure descriptors. This provides enormous performance benefits; however, it means that if you change the underlying type definition of an array type in the database, the cached descriptor for that array type will become stale and your application will receive a `SQLException`.

Prepared and Callable Statement Setter Methods

The `OraclePreparedStatement` and `OracleCallableStatement` classes support `setARRAY()` and `setArray()` methods to take updated `ARRAY` objects as bind variables and pass them to the database. You can also use the `setObject()` method. These methods take as input a `String` parameter name or `int` parameter index as well as, respectively, an `oracle.sql.ARRAY` instance or a `java.sql.Array` instance.

ARRAY Descriptors and ARRAY Class Functionality

The section introduces `ARRAY` descriptors and lists methods of the `ARRAY` class to provide an overview of its functionality.

ARRAY Descriptors

Creating and using an `ARRAY` object requires the existence of a descriptor—an instance of the `oracle.sql.ArrayDescriptor` class—to exist for the SQL type of the collection being materialized in the array. You need only one `ArrayDescriptor` object for any number of `ARRAY` objects that correspond to the same SQL type.

`ARRAY` descriptors are further discussed in "Creating ARRAY Objects and Descriptors" on page 16-8.

ARRAY Class Methods

The `oracle.sql.ARRAY` class includes the following methods:

- `getDescriptor()`: Returns the `ArrayDescriptor` object that describes the array type.
- `getArray()`: Retrieves the contents of the array in "default" JDBC types. If it retrieves an array of objects, then `getArray()` uses the default type map of the database connection object to determine the types.
- `getOracleArray()`: Identical to `getArray()`, but retrieves the elements in `oracle.sql.*` format.
- `getBaseType()`: Returns the SQL typecode for the array elements (see "Class oracle.jdbc.OracleTypes" on page 10-17 for information about typecodes).
- `getBaseTypeName()`: Returns the SQL type name of the elements of this array.
- `getSQLTypeName()` (Oracle extension): Returns the fully qualified SQL type name of the array as a whole.
- `getResultSet()`: Materializes the array elements as a result set.
- `getJavaSQLConnection()`: Returns the connection instance (`java.sql.Connection`) associated with this array.
- `length()`: Returns the number of elements in the array.

Note: As an example of the difference between `getBaseTypeName()` and `getSQLTypeName()`, if you define `ARRAY_OF_PERSON` as the array type for an array of `PERSON` objects in the `SCOTT` schema, then `getBaseTypeName()` would return "SCOTT.PERSON" and `getSQLTypeName()` would return "SCOTT.ARRAY_OF_PERSON".

ARRAY Performance Extension Methods

This section discusses the following topics:

- Accessing oracle.sql.ARRAY Elements as Arrays of Java Primitive Types
- ARRAY Automatic Element Buffering
- ARRAY Automatic Indexing

Accessing oracle.sql.ARRAY Elements as Arrays of Java Primitive Types

The `oracle.sql.ARRAY` class contains methods that return array elements as Java primitive types. These methods allow you to access collection elements more efficiently than accessing them as `Datum` instances and then converting each `Datum` instance to its Java primitive value.

> **Note:** These specialized methods of the `oracle.sql.ARRAY` class are restricted to numeric collections.

Here are the methods:

- ```
  public int[] getIntArray()throws SQLException

  public int[] getIntArray(long index, int count)
     throws SQLException
  ```
- ```
  public long[] getLongArray()throws SQLException

  public long[] getLongArray(long index, int count)
     throws SQLException
  ```
- ```
  public float[] getFloatArray()throws SQLException

  public float[] getFloatArray(long index, int count)
     throws SQLException
  ```
- ```
  public double[] getDoubleArray()throws SQLException

  public double[] getDoubleArray(long index, int count)
     throws SQLException
  ```
- ```
  public short[] getShortArray()throws SQLException

  public short[] getShortArray(long index, int count)
     throws SQLException
  ```

Each method using the first signature returns collection elements as an *XXX*`[]`, where *XXX* is a Java primitive type. Each method using the second signature returns a slice of the collection containing the number of elements specified by `count`, starting at the `index` location.

ARRAY Automatic Element Buffering

The Oracle JDBC driver provides public methods to enable and disable buffering of `ARRAY` contents. (See "STRUCT Automatic Attribute Buffering" on page 13-7 for a discussion of how to buffer `STRUCT` attributes.)

The following methods are included with the `oracle.sql.ARRAY` class:

- ```
  public void setAutoBuffering(boolean enable)
  ```
- ```
  public boolean getAutoBuffering()
  ```

The `setAutoBuffering()` method enables or disables auto-buffering. The `getAutoBuffering()` method returns the current auto-buffering mode. By default, auto-buffering is disabled.

It is advisable to enable auto-buffering in a JDBC application when the `ARRAY` elements will be accessed more than once by the `getAttributes()` and `getArray()` methods (presuming the `ARRAY` data is able to fit into the JVM memory without overflow).
  ```

Important: Buffering the converted elements may cause the JDBC application to consume a significant amount of memory.

When you enable auto-buffering, the `oracle.sql.ARRAY` object keeps a local copy of all the converted elements. This data is retained so that a second access of this information does not require going through the data format conversion process.

ARRAY Automatic Indexing

If an array is in auto-indexing mode, the array object maintains an index table to hasten array element access.

The `oracle.sql.ARRAY` class contains the following methods to support automatic array-indexing:

- ```
  public synchronized void setAutoIndexing
     (boolean enable, int direction)
     throws SQLException
  ```
- ```
  public synchronized void setAutoIndexing
     (boolean enable)
     throws SQLException
  ```

The `setAutoIndexing()` method sets the auto-indexing mode for the `oracle.sql.ARRAY` object. The `direction` parameter gives the array object a hint: specify this parameter to help the JDBC driver determine the best indexing scheme. The following are the values you can specify for the `direction` parameter:

- `ARRAY.ACCESS_FORWARD`
- `ARRAY.ACCESS_REVERSE`
- `ARRAY.ACCESS_UNKNOWN`

The `setAutoIndexing(boolean)` method signature sets the access direction as `ARRAY.ACCESS_UNKNOWN` by default.

By default, auto-indexing is not enabled. For a JDBC application, enable auto-indexing for `ARRAY` objects if random access of array elements may occur through the `getArray()` and `getResultSet()` methods.

Creating and Using Arrays

This section discusses how to create array objects and how to retrieve and pass collections as array objects, including the following topics.

- Creating ARRAY Objects and Descriptors
- Retrieving an Array and Its Elements
- Passing Arrays to Statement Objects

Creating ARRAY Objects and Descriptors

This section describes how to create ARRAY objects and descriptors and lists useful methods of the ArrayDescriptor class.

Steps in Creating ArrayDescriptor and ARRAY Objects

This section describes how to construct an oracle.sql.ARRAY object. To do this, you must:

1. Create an ArrayDescriptor object (if one does not already exist) for the array.
2. Use the ArrayDescriptor object to construct the oracle.sql.ARRAY object for the array you want to pass.

An ArrayDescriptor is an object of the oracle.sql.ArrayDescriptor class and describes the SQL type of an array. Only one array descriptor is necessary for any one SQL type. The driver caches ArrayDescriptor objects to avoid recreating them if the SQL type has already been encountered. You can reuse the same descriptor object to create multiple instances of an oracle.sql.ARRAY object for the same array type.

Collections are strongly typed. Oracle supports only named collections, that is, a collection given a SQL type name. For example, when you create a collection with the CREATE TYPE statement:

```
CREATE TYPE num_varray AS varray(22) OF NUMBER(5,2);
```

Where NUM_VARRAY is the SQL type name for the collection type.

Note: The name of the collection type is not the same as the type name of the elements. For example:

```
CREATE TYPE person AS object
            (c1 NUMBER(5), c2 VARCHAR2(30));
CREATE TYPE array_of_persons AS varray(10)
          OF person;
```

In the preceding statements, the SQL name of the collection type is ARRAY_OF_PERSON. The SQL name of the collection elements is PERSON.

Before you can construct an Array object, an ArrayDescriptor must first exist for the given SQL type of the array. If an ArrayDescriptor does not exist, then you must construct one by passing the SQL type name of the collection type and your Connection object (which JDBC uses to go to the database to gather meta data) to the constructor.

```
ArrayDescriptor arraydesc = ArrayDescriptor.createDescriptor
                                          (sql_type_name, connection);
```

where *sql_type_name* is the type name of the array and *connection* is your Connection object.

Once you have your ArrayDescriptor object for the SQL type of the array, you can construct the ARRAY object. To do this, pass in the array descriptor, your connection object, and a Java object containing the individual elements you want the array to contain.

```
ARRAY array = new ARRAY(arraydesc, connection, elements);
```

Where `arraydesc` is the array descriptor created previously, `connection` is your connection object, and `elements` is a Java array. The two possibilities for the contents of `elements` are:

- an array of Java primitives—for example, `int[]`
- an array of Java objects, such as *xxx*`[]` where *xxx* is the name of a Java class—for example, `Integer[]`

> **Note:** The `setARRAY()`, `setArray()`, and `setObject()` methods of the `OraclePreparedStatement` class take an object of the type `oracle.sql.ARRAY` as an argument, not an array of objects.

Creating Multi-Level Collections

As with single-level collections, the JDBC application can create an `oracle.sql.ARRAY` instance to represent a multi-level collection, and then send the instance to the database. The `oracle.sql.ARRAY` constructor is defined as follows:

```
public ARRAY(ArrayDescriptor type, Connection conn, Object elements)
throws SQLException
```

The first argument is an `oracle.sql.ArrayDescriptor` object that describes the multi-level collection type. The second argument is the current database connection. And the third argument is a `java.lang.Object` that holds the multi-level collection elements. This is the same constructor used to create single-level collections, but enhanced to create multi-level collections as well. The elements parameter can now be either a one dimension array or a nested Java array.

To create a single-level collection, the elements are a one dimensional Java array. To create a multi-level collection, the elements can be either an array of `oracle.sql.ARRAY[]` elements or a nested Java array or the combinations.

The following code shows how to create collection types with a nested Java array:

```
Connection conn = ...;          // make a JDBC connection

// create the collection types
Statement stmt = conn.createStatement ();
stmt.execute ("CREATE TYPE varray1 AS VARRAY(10) OF NUMBER(12, 2)"); // one
                                                                     // layer
stmt.execute ("CREATE TYPE varray2 AS VARRAY(10) OF varray1"); // two layers
stmt.execute ("CREATE TYPE varray3 AS VARRAY(10) OF varray2"); // three layers
stmt.execute ("CREATE TABLE tab2 (col1 index, col2 value)");
stmt.close ();

// obtain a type descriptor of "SCOTT.VARRAY3"
ArrayDescriptor desc = ArrayDescriptor.createDescriptor("SCOTT.VARRAY3", conn);

// prepare the multi level collection elements as a nested Java array
int[][][] elems = { {{1}, {1, 2}}, {{2}, {2, 3}}, {{3}, {3, 4}} };

// create the ARRAY by calling the constructor
ARRAY array3 = new ARRAY (desc, conn, elems);

// some operations
...
```

```
// close the database connection
conn.close();
```

In the above example, another implementation is to prepare the `elems` as a Java array of `oracle.sql.ARRAY[]` elements, and each `oracle.sql.ARRAY[]` element represents a `SCOTT.VARRAY3`.

Using ArrayDescriptor Methods

An `ARRAY` descriptor can be referred to as a *type object*. It has information about the SQL name of the underlying collection, the typecode of the array's elements, and, if it is an array of structured objects, the SQL name of the elements. The descriptor also contains the information on about to convert to and from the given type. You need only one descriptor object for any one type, then you can use that descriptor to create as many arrays of that type as you want.

The `ArrayDescriptor` class has the following methods for retrieving an element's typecode and type name:

- `createDescriptor()`: This is a factory for `ArrayDescriptor` instances; looks up the name in the database and determine the characteristics of the array.
- `getBaseType()`: Returns the integer typecode associated with this `ARRAY` descriptor (according to integer constants defined in the `OracleTypes` class, which "Package oracle.jdbc" on page 10-11 describes).
- `getBaseName()`: Returns a string with the type name associated with this array element if it is a `STRUCT` or `REF`.
- `getArrayType()`: Returns an integer indicating whether the array is a VARRAY or nested table. `ArrayDescriptor.TYPE_VARRAY` and `ArrayDescriptor.TYPE_NESTED_TABLE` are the possible return values.
- `getMaxLength()`: Returns the maximum number of elements for this array type.
- `getJavaSQLConnection()`: Returns the connection instance (`java.sql.Connection`) that was used in creating the `ARRAY` descriptor (a new descriptor must be created for each connection instance).

> **Note:** In releases prior to Oracle9*i*, you could not use a collection within a collection. You could, however, use a structured object with a collection attribute, or a collection with structured object elements. In Oracle9*i* and higher releases, you can use a collection within a collection.

Serializable ARRAY Descriptors

As "Steps in Creating ArrayDescriptor and ARRAY Objects" on page 16-8 discusses, when you create an `ARRAY` object, you first must create an `ArrayDescriptor` object. Create the `ArrayDescriptor` object by calling the `ArrayDescriptor.createDescriptor()` method. The `oracle.sql.ArrayDescriptor` class is serializable, meaning that you can write the state of an `ArrayDescriptor` object to an output stream for later use. Recreate the `ArrayDescriptor` object by reading its serialized state from an input stream. This is referred to as *deserializing*. With the `ArrayDescriptor` object serialized, you do not need to call the `createDescriptor()` method—simply deserialize the `ArrayDescriptor` object.

It is advisable to serialize an ARRAYDESCRIPTOR object when the object type is complex but not changed often.

If you create an ARRAYDESCRIPTOR object through deserialization, you must provide the appropriate database connection instance for the ARRAYDESCRIPTOR object using the SETCONNECTION() method.

The following code furnishes the connection instance for an ARRAYDESCRIPTOR object:

```
public void setConnection (Connection conn) throws SQLException
```

> **Note:** The JDBC driver does not verify that the connection object from the SETCONNECTION() method connects to the same database from which the type descriptor was initially derived.

Retrieving an Array and Its Elements

This section first discusses how to retrieve an ARRAY instance as a whole from a result set, and then how to retrieve the elements from the ARRAY instance.

Retrieving the Array

You can retrieve a SQL array from a result set by casting the result set to an ORACLERESULTSET object and using the GETARRAY() method, which returns an ORACLE.SQL.ARRAY object. If you want to avoid casting the result set, then you can get the data with the standard GETOBJECT() method specified by the JAVA.SQL.RESULTSET interface, and cast the output to an ORACLE.SQL.ARRAY object.

Data Retrieval Methods

Once you have the array in an ARRAY object, you can retrieve the data using one of these three overloaded methods of the ORACLE.SQL.ARRAY class:

- GETARRAY()
- GETORACLEARRAY()
- GETRESULTSET()

Oracle also provides methods that enable you to retrieve all the elements of an array, or a subset.

> **Note:** In case you are working with an array of structured objects, Oracle provides versions of these three methods that enable you to specify a type map so that you can choose how to map the objects to Java.

getOracleArray() The GETORACLEARRAY() method is an Oracle-specific extension that is not specified in the standard ARRAY interface (JAVA.SQL.ARRAY). The GETORACLEARRAY() method retrieves the element values of the array into a DATUM[] array. The elements are of the ORACLE.SQL.* datatype corresponding to the SQL type of the data in the original array.

For an array of structured objects, this method will use ORACLE.SQL.STRUCT instances for the elements.

Oracle also provides a `getOracleArray(index, count)` method to get a subset of the array elements.

getResultSet() The `getResultSet()` method returns a result set that contains elements of the array designated by the `ARRAY` object. The result set contains one row for each array element, with two columns in each row. The first column stores the index into the array for that element, and the second column stores the element value. In the case of VARRAYs, the index represents the position of the element in the array. In the case of nested tables, which are by definition unordered, the index reflects only the return order of the elements in the particular query.

Oracle recommends using `getResultSet()` when getting data from nested tables. Nested tables can have an unlimited number of elements. The `ResultSet` object returned by the method initially points at the first row of data. You get the contents of the nested table by using the `next()` method and the appropriate `getXXX()` method. In contrast, `getArray()` returns the entire contents of the nested table at one time.

The `getResultSet()` method uses the connection's default type map to determine the mapping between the SQL type of the Oracle object and its corresponding Java datatype. If you do not want to use the connection's default type map, another version of the method, `getResultSet(map)`, enables you to specify an alternate type map.

Oracle also provides the `getResultSet(index, count)` and `getResultSet(index, count, map)` methods to retrieve a subset of the array elements.

getArray() The `getArray()` method is a standard JDBC method that returns the array elements into a `java.lang.Object` instance that you can cast as appropriate (see "Comparing the Data Retrieval Methods" on page 16-12). The elements are converted to the Java types corresponding to the SQL type of the data in the original array.

Oracle also provides a `getArray(index, count)` method to retrieve a subset of the array elements.

Comparing the Data Retrieval Methods

If you use `getOracleArray()` to return the array elements, the use by that method of `oracle.sql.Datum` instances avoids the expense of data conversion from SQL to Java. The data inside a `Datum` (or subclass) instance remains in raw SQL format.

If you use `getResultSet()` to return an array of primitive datatypes, then the JDBC driver returns a `ResultSet` object that contains, for each element, the index into the array for the element and the element value. For example:

```
ResultSet rset = intArray.getResultSet();
```

In this case, the result set contains one row for each array element, with two columns in each row. The first column stores the index into the array; the second column stores the element value.

If you use `getArray()` to retrieve an array of primitive datatypes, then a `java.lang.Object` that contains the element values is returned. The elements of this array are of the Java type corresponding to the SQL type of the elements. For example:

```
BigDecimal[] values = (BigDecimal[]) intArray.getArray();
```

Where `intArray` is an `oracle.sql.ARRAY`, corresponding to a VARRAY of type `NUMBER`. The `values` array contains an array of elements of type

java.math.BigDecimal, because the SQL NUMBER datatype maps to Java BigDecimal by default, according to the Oracle JDBC drivers.

> **Note:** Using BigDecimal is a resource-intensive operation in Java. Because Oracle JDBC maps numeric SQL data to BigDecimal by default, using getArray() may impact performance, and is not recommended for numeric collections.

Retrieving Elements of a Structured Object Array According to a Type Map

By default, if you are working with an array whose elements are structured objects, and you use getArray() or getResultSet(), then the Oracle objects in the array will be mapped to their corresponding Java datatypes according to the default mapping. This is because these methods use the connection's default type map to determine the mapping.

However, if you do not want default behavior, then you can use the getArray(*map*) or getResultSet(*map*) method to specify a type map that contains alternate mappings. If there are entries in the type map corresponding to the Oracle objects in the array, then each object in the array is mapped to the corresponding Java type specified in the type map. For example:

```
Object[] object = (Object[])objArray.getArray(map);
```

Where objArray is an oracle.sql.ARRAY object and map is a java.util.Map object.

If the type map does not contain an entry for a particular Oracle object, then the element is returned as an oracle.sql.STRUCT object.

The getResultSet(*map*) method behaves similarly to the getArray(*map*) method.

For more information on using type maps with arrays, see "Using a Type Map to Map Array Elements" on page 16-17.

Retrieving a Subset of Array Elements

If you do not want to retrieve the entire contents of an array, then you can use signatures of getArray(), getResultSet(), and getOracleArray() that let you retrieve a subset. To retrieve a subset of the array, pass in an index and a count to indicate where in the array you want to start and how many elements you want to retrieve. As described above, you can specify a type map or use the default type map for your connection to convert to Java types. For example:

```
Object object = arr.getArray(index, count, map);
Object object = arr.getArray(index, count);
```

Similar examples using getResultSet() are:

```
ResultSet rset = arr.getResultSet(index, count, map);
ResultSet rset = arr.getResultSet(index, count);
```

A similar example using `getOracleArray()` is:

```
Datum arr = arr.getOracleArray(index, count);
```

Where *arr* is an `oracle.sql.ARRAY` object, *index* is type `long`, *count* is type `int`, and *map* is a `java.util.Map` object.

> **Note:** There is no performance advantage in retrieving a subset of an array, as opposed to the entire array.

Retrieving Array Elements into an oracle.sql.Datum Array

Use `getOracleArray()` to return an `oracle.sql.Datum[]` array. The elements of the returned array will be of the `oracle.sql.*` type that correspond to the SQL datatype of the elements of the original array. For example:

```
Datum arraydata[] = arr.getOracleArray();
```

Where `arr` is an `oracle.sql.ARRAY` object.

The following example assumes that a connection object `conn` and a statement object `stmt` have already been created. In the example, an array with the SQL type name `NUM_ARRAY` is created to store a VARRAY of `NUMBER` data. The `NUM_ARRAY` is in turn stored in a table `VARRAY_TABLE`.

A query selects the contents of the `VARRAY_TABLE`. The result set is cast to an `OracleResultSet` object; `getARRAY()` is applied to it to retrieve the array data into `my_array`, which is an `oracle.sql.ARRAY` object.

Because `my_array` is of type `oracle.sql.ARRAY`, you can apply the methods `getSQLTypeName()` and `getBaseType()` to it to return the name of the SQL type of each element in the array and its integer code.

The program then prints the contents of the array. Because the contents of `my_array` are of the SQL datatype `NUMBER`, it must first be cast to the `BigDecimal` datatype. In the `for` loop, the individual values of the array are cast to `BigDecimal` and printed to standard output.

```
stmt.execute ("CREATE TYPE num_varray AS VARRAY(10) OF NUMBER(12, 2)");
stmt.execute ("CREATE TABLE varray_table (col1 num_varray)");
stmt.execute ("INSERT INTO varray_table VALUES (num_varray(100, 200))");

ResultSet rs = stmt.executeQuery("SELECT * FROM varray_table");
ARRAY my_array = ((OracleResultSet)rs).getARRAY(1);

// return the SQL type names, integer codes,
// and lengths of the columns
System.out.println ("Array is of type " + array.getSQLTypeName());
System.out.println ("Array element is of typecode " + array.getBaseType());
System.out.println ("Array is of length " + array.length());

// get Array elements
BigDecimal[] values = (BigDecimal[]) my_array.getArray();

for (int i=0; i<values.length; i++)
{
   BigDecimal out_value = (BigDecimal) values[i];
   System.out.println(">> index " + i + " = " + out_value.intValue());
}
```

Note that if you use `getResultSet()` to obtain the array, you would first get the result set object, then use the `next()` method to iterate through it. Notice the use of the parameter indexes in the `getInt()` method to retrieve the element index and the element value.

```
ResultSet rset = my_array.getResultSet();
while (rset.next())
{
    // The first column contains the element index and the
    // second column contains the element value
    System.out.println(">> index " + rset.getInt(1)+" = " + rset.getInt(2));
}
```

Accessing Multi-Level Collection Elements

The `oracle.sql.ARRAY` class provides three methods (which can be overloaded) to access collection elements. The JDBC drivers extend these methods to support multi-level collections. The three methods are the following:

- `getArray()` method : JDBC standard
- `getOracleArray()` method : Oracle extension
- `getResultSet()` method : JDBC standard

The `getArray()` method returns a Java array that holds the collection elements. The array element type is determined by the collection element type and the JDBC default conversion matrix.

For example, the `getArray()` method returns a `java.math.BigDecimal` array for collection of SQL `NUMBER`. The `getOracleArray()` method returns a Datum array that holds the collection elements in Datum format. For multi-level collections, the `getArray()` and `getOracleArray()` methods both return a Java array of `oracle.sql.ARRAY` elements.

The `getResultSet()` method returns a `ResultSet` object that wraps the multi-level collection elements. For multi-level collections, the JDBC applications use the `getObject()`, `getARRAY()`, or `getArray()` method of the `ResultSet` class to access the collection elements as instances of `oracle.sql.ARRAY`.

The following code shows how to use the `getOracleArray()`, `getArray()`, and `getResultSet()` methods:

```
Connection conn = ...;          // make a JDBC connection
Statement stmt = conn.createStatement ();
ResultSet rset = stmt.executeQuery ("select col2 from tab2 where idx=1");

while (rset.next())
{
  ARRAY varray3 = (ARRAY) rset.getObject (1);
  Object varrayElems = varray3.getArray (1);
// access array elements of "varray3"
  Datum[] varray3Elems = (Datum[]) varrayElems;
```

```
  for (int i=0; i<varray3Elems.length; i++)
  {
    ARRAY varray2 = (ARRAY) varray3Elems[i];
    Datum[] varray2Elems = varray2.getOracleArray();
    // access array elements of  "varray2"

    for (int j=0; j<varray2Elems.length; j++)
    {
      ARRAY varray1 = (ARRAY) varray2Elems[j];
      ResultSet varray1Elems = varray1.getResultSet();
      // access array elements   of "varray1"

      while (varray1Elems.next())
        System.out.println ("idx="+varray1Elems.getInt(1)+"
          value="+varray1Elems.getInt(2));
    }
  }
}
rset.close ();
stmt.close ();
conn.close ();
```

Passing Arrays to Statement Objects

This section discusses how to pass arrays to prepared statement objects or callable statement objects.

Passing an Array to a Prepared Statement

Pass an array to a prepared statement as follows (use similar steps to pass an array to a callable statement). Note that you can use arrays as either `IN` or `OUT` bind variables.

1. Construct an `ArrayDescriptor` object for the SQL type that the array will contain (unless one has already been created for this SQL type). See "Steps in Creating ArrayDescriptor and ARRAY Objects" on page 16-8 for information about creating `ArrayDescriptor` objects.

   ```
   ArrayDescriptor descriptor = ArrayDescriptor.createDescriptor
                                    (sql_type_name, connection);
   ```

   Where *`sql_type_name`* is a Java string specifying the user-defined SQL type name of the array, and *`connection`* is your `Connection` object. See "Oracle Extensions for Collections (Arrays)" on page 16-1 for information about SQL typenames.

2. Define the array that you want to pass to the prepared statement as an `oracle.sql.ARRAY` object.

   ```
   ARRAY array = new ARRAY(descriptor, connection, elements);
   ```

   Where *`descriptor`* is the `ArrayDescriptor` object previously constructed and *`elements`* is a `java.lang.Object` containing a Java array of the elements.

3. Create a `java.sql.PreparedStatement` object containing the SQL statement to execute.

4. Cast your prepared statement to an `OraclePreparedStatement` and use the `setARRAY()` method of the `OraclePreparedStatement` object to pass the array to the prepared statement.

   ```
   (OraclePreparedStatement)stmt.setARRAY(parameterIndex, array);
   ```

Where *parameterIndex* is the parameter index, and *array* is the `oracle.sql.ARRAY` object you constructed previously.

5. Execute the prepared statement.

Passing an Array to a Callable Statement

To retrieve a collection as an `OUT` parameter in PL/SQL blocks, execute the following to register the bind type for your `OUT` parameter.

1. Cast your callable statement to an `OracleCallableStatement`:

```
OracleCallableStatement ocs =
   (OracleCallableStatement)conn.prepareCall("{? = call func()}");
```

2. Register the `OUT` parameter with this form of the `registerOutParameter()` method:

```
ocs.registerOutParameter
        (int param_index, int sql_type, string sql_type_name);
```

Where *param_index* is the parameter index, *sql_type* is the SQL typecode, and *sql_type_name* is the name of the array type. In this case, the *sql_type* is `OracleTypes.ARRAY`.

3. Execute the call:

```
ocs.execute();
```

4. Get the value:

```
oracle.sql.ARRAY array = ocs.getARRAY(1);
```

Using a Type Map to Map Array Elements

If your array contains Oracle objects, then you can use a type map to associate the objects in the array with the corresponding Java class. If you do not specify a type map, or if the type map does not contain an entry for a particular Oracle object, then each element is returned as an `oracle.sql.STRUCT` object.

If you want the type map to determine the mapping between the Oracle objects in the array and their associated Java classes, then you must add an appropriate entry to the map. For instructions on how to add entries to an existing type map or how to create a new type map, see "Understanding Type Maps for SQLData Implementations" on page 13-8.

The following example illustrates how you can use a type map to map the elements of an array to a custom Java object class. In this case, the array is a nested table. The example begins by defining an `EMPLOYEE` object that has a name attribute and employee number attribute. `EMPLOYEE_LIST` is a nested table type of `EMPLOYEE` objects. Then an `EMPLOYEE_TABLE` is created to store the names of departments within a corporation and the employees associated with each department. In the `EMPLOYEE_TABLE`, the employees are stored in the form of `EMPLOYEE_LIST` tables.

```
stmt.execute("CREATE TYPE EMPLOYEE AS OBJECT
            (EmpName VARCHAR2(50),EmpNo INTEGER))");

stmt.execute("CREATE TYPE EMPLOYEE_LIST AS TABLE OF EMPLOYEE");

stmt.execute("CREATE TABLE EMPLOYEE_TABLE (DeptName VARCHAR2(20),
     Employees EMPLOYEE_LIST) NESTED TABLE Employees STORE AS ntable1");
```

```
stmt.execute("INSERT INTO EMPLOYEE_TABLE VALUES ("SALES", EMPLOYEE_LIST
            (EMPLOYEE('Susan Smith', 123), EMPLOYEE('Scott Tiger', 124)))");
```

If you want to retrieve all the employees belonging to the SALES department into an array of instances of the custom object class EmployeeObj, then you must add an entry to the type map to specify mapping between the EMPLOYEE SQL type and the EmployeeObj custom object class.

To do this, first create your statement and result set objects, then select the EMPLOYEE_LIST associated with the SALES department into the result set. Cast the result set to OracleResultSet so you can use the getARRAY() method to retrieve the EMPLOYEE_LIST into an ARRAY object (employeeArray in the example below).

The EmployeeObj custom object class in this example implements the SQLData interface.

```
Statement s = conn.createStatement();
OracleResultSet rs = (OracleResultSet)s.executeQuery
       ("SELECT Employees FROM employee_table WHERE DeptName = 'SALES'");

// get the array object
ARRAY employeeArray = ((OracleResultSet)rs).getARRAY(1);
```

Now that you have the EMPLOYEE_LIST object, get the existing type map and add an entry that maps the EMPLOYEE SQL type to the EmployeeObj Java type.

```
// add type map entry to map SQL type
// "EMPLOYEE" to Java type "EmployeeObj"
Map map = conn.getTypeMap();
map.put("EMPLOYEE", Class.forName("EmployeeObj"));
```

Next, retrieve the SQL EMPLOYEE objects from the EMPLOYEE_LIST. To do this, invoke the getArray() method of the employeeArray array object. This method returns an array of objects. The getArray() method returns the EMPLOYEE objects into the employees object array.

```
// Retrieve array elements
Object[] employees = (Object[]) employeeArray.getArray();
```

Finally, create a loop to assign each of the EMPLOYEE SQL objects to the EmployeeObj Java object emp.

```
// Each array element is mapped to EmployeeObj object.
for (int i=0; i<employees.length; i++)
{
   EmployeeObj emp = (EmployeeObj) employees[i];
   ...
}
```

Custom Collection Classes with JPublisher

This chapter primarily describes the functionality of the oracle.sql.ARRAY class, but it is also possible to access Oracle collections through custom Java classes or, more specifically, *custom collection classes*.

You can create custom collection classes yourself, but the most convenient way is to use the Oracle JPublisher utility. Custom collection classes generated by JPublisher offer all the functionality described earlier in this chapter, as well as the following advantages (it is also possible to implement such functionality yourself):

- They are strongly typed. This can help you find coding errors during compilation that might not otherwise be discovered until runtime.
- They can be changeable, or *mutable*. Custom collection classes produced by JPublisher, unlike the `ARRAY` class, allow you to get and set individual elements using the `getElement()` and `setElement()` methods. (This is also something you could implement in a custom collection class yourself.)

A custom collection class must satisfy three requirements:

- It must implement the `oracle.sql.ORAData` interface described under "Creating and Using Custom Object Classes for Oracle Objects" on page 13-7. Note that the standard JDBC `SQLData` interface, which is an alternative for custom object classes, is not intended for custom collection classes.
- It, or a companion class, must implement the `oracle.sql.ORADataFactory` interface, for creating instances of the custom collection class.
- It must have a means of storing the collection data. Typically it will directly or indirectly include an `oracle.sql.ARRAY` attribute for this purpose (this is the case with a JPublisher-produced custom collection class).

A JPublisher-generated custom collection class implements `ORAData` and `ORADataFactory` and indirectly includes an `oracle.sql.ARRAY` attribute. The custom collection class will have an `oracle.jpub.runtime.MutableArray` attribute. The `MutableArray` class has an `oracle.sql.ARRAY` attribute.

Note: When you use JPublisher to create a custom collection class, you must use the `ORAData` implementation. This will be true if JPublisher's `-usertypes` mapping option is set to `oracle`, which is the default.

You cannot use a `SQLData` implementation for a custom collection class (that implementation is for custom object classes only). Setting the `-usertypes` mapping option to `jdbc` is invalid.

As an example of custom collection classes being strongly typed, if you define an Oracle collection `MYVARRAY`, then JPublisher can generate a `MyVarray` custom collection class. Using `MyVarray` instances, instead of generic `oracle.sql.ARRAY` instances, makes it easier to catch errors during compilation instead of at runtime—for example, if you accidentally assign some other kind of array into a `MyVarray` variable.

If you do not use custom collection classes, then you would use standard `java.sql.Array` instances (or `oracle.sql.ARRAY` instances) to map to your collections.

For more information about JPublisher, see "Using JPublisher to Create Custom Object Classes" on page 13-32, or refer to the *Oracle Database JPublisher User's Guide*.

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Result Set Enhancements

Standard JDBC 2.0 features in JDK 1.2.x include enhancements to result set functionality—processing forward or backward, positioning relatively or absolutely, seeing changes to the database made internally or externally, and updating result set data and then copying the changes to the database.

This chapter discusses these features, including the following topics:

For more general and conceptual information about JDBC 2.0 result set enhancements, refer to the Sun Microsystems JDBC 2.0 API specification.

Overview

This section provides an overview of JDBC 2.0 result set functionality and categories, and some discussion of implementation requirements for the Oracle JDBC drivers.

Result Set Functionality and Result Set Categories Supported in JDBC 2.0

Result set functionality in JDBC 2.0 includes enhancements for scrollability and positioning, sensitivity to changes by others, and updatability.

- Scrollability, positioning, and sensitivity are determined by the *result set type*.
- Updatability is determined by the *concurrency type*.

Specify the desired result set type and concurrency type when you create the statement object that will produce the result set.

Together, the various result set types and concurrency types provide for six different categories of result set.

This section provides an overview of these enhancements, types, and categories.

Scrollability, Positioning, and Sensitivity

Scrollability refers to the ability to move backward as well as forward through a result set. Associated with scrollability is the ability to move to any particular position in the result set, through either *relative positioning* or *absolute positioning*.

Relative positioning allows you to move a specified number of rows forward or backward from the current row. Absolute positioning allows you to move to a specified row number, counting from either the beginning or the end of the result set.

Under JDBC 2.0 (in JDK 1.2.x), scrollable/positionable result sets are also available.

When creating a scrollable/positionable result set, you must also specify *sensitivity*. This refers to the ability of a result set to detect and reveal changes made to the underlying database from outside the result set.

A *sensitive* result set can see changes made to the database while the result set is open, providing a dynamic view of the underlying data. Changes made to the underlying columns values of rows in the result set are visible.

An *insensitive* result set is *not* sensitive to changes made to the database while the result set is open, providing a static view of the underlying data. You would need to retrieve a new result set to see changes made to the database.

Result Set Types for Scrollability and Sensitivity

When you create a result set under JDBC 2.0 functionality, you must choose a particular result set type to specify whether the result set is scrollable/positional and sensitive to underlying database changes.

If the JDBC 1.0 functionality is all you desire, JDBC 2.0 continues to support this through the *forward-only* result set type. A forward-only result set cannot be sensitive.

If you want a scrollable result set, you must also specify sensitivity. Specify the *scroll-sensitive* type for the result set to be scrollable and sensitive to underlying changes. Specify the *scroll-insensitive* type for the result set to be scrollable but not sensitive to underlying changes.

To summarize, the following three result set types are available with JDBC 2.0:

- forward-only (JDBC 1.0 functionality—not scrollable, not positionable, and not sensitive)
- scroll-sensitive (scrollable and positionable; also sensitive to underlying database changes)
- scroll-insensitive (scrollable and positionable but not sensitive to underlying database changes)

> **Note:** The sensitivity of a scroll-sensitive result set (how often it is updated to see external changes) is affected by fetch size. See Fetch Size on page 17-15 and "Oracle Implementation of Scroll-Sensitive Result Sets" on page 17-20.

Updatability

Updatability refers to the ability to update data in a result set and then (presumably) copy the changes to the database. This includes inserting new rows into the result set or deleting existing rows.

Updatability might also require database write locks to mediate access to the underlying database. Because you cannot have multiple write locks concurrently, updatability in a result set is associated with *concurrency* in database access.

Result sets can optionally be updatable under JDBC 2.0

> **Note:** Updatability is independent of scrollability and sensitivity, although it is typical for an updatable result set to also be scrollable so that you can position it to particular rows that you want to update or delete.

Concurrency Types for Updatability

The concurrency type of a result set determines whether it is updatable. Under JDBC 2.0, the following concurrency types are available:

- updatable (updates, inserts, and deletes can be performed on the result set and copied to the database)
- read-only (the result set cannot be modified in any way)

Summary of Result Set Categories

Because scrollability and sensitivity are independent of updatability, the three result set types and two concurrency types combine for a total of six *result set categories*:

- forward-only/read-only
- forward-only/updatable
- scroll-sensitive/read-only
- scroll-sensitive/updatable
- scroll-insensitive/read-only
- scroll-insensitive/updatable

> **Note:** A forward-only updatable result set has no positioning functionality. You can only update rows as you iterate through them with the `next()` method.

Oracle JDBC Implementation Overview for Result Set Enhancements

This section discusses key aspects of the Oracle JDBC implementation of result set enhancements for scrollability—through use of a client-side cache—and for updatability—through use of ROWIDs.

It is permissible for customers to implement their own client-side caching mechanism, and Oracle provides an interface to use in doing so.

Oracle JDBC Implementation for Result Set Scrollability

Because the underlying server does *not* support scrollable cursors, Oracle JDBC must implement scrollability in a separate layer.

It is important to be aware that this is accomplished by using a client-side memory cache to store rows of a scrollable result set.

> **Important:** Because all rows of any scrollable result set are stored in the client-side cache, a situation where the result set contains many rows, many columns, or very large columns might cause the client-side Java virtual machine to fail. *Do not specify scrollability for a large result set*.

Scrollable cursors in the Oracle server, and therefore a server-side cache, will be supported in a future Oracle release.

Oracle JDBC Implementation for Result Set Updatability

To support updatability, Oracle JDBC uses ROWIDs to uniquely identify database rows that appear in a result set. For every query into an updatable result set, the Oracle JDBC driver automatically retrieves the ROWID along with the columns you select.

> **Note:** Client-side caching is not required by updatability in and of itself. In particular, a forward-only updatable result set will not require a client-side cache.

Implementing a Custom Client-Side Cache for Scrollability

There is some flexibility in how to implement client-side caching in support of JDBC 2.0 scrollable result sets.

Although Oracle JDBC provides a complete implementation, it also supplies an interface, OracleResultSetCache, that you can implement as desired:

```
public interface OracleResultSetCache
{
  /**
   * Save the data in the i-th row and j-th column.
   */
  public void put (int i, int j, Object value) throws IOException;

  /**
   * Return the data stored in the i-th row and j-th column.
   */
  public Object get (int i, int j) throws IOException;

  /**
   * Remove the i-th row.
```

```
   */
  public void remove (int i) throws IOException;

  /**
   * Remove the data stored in i-th row and j-th column
   */
  public void remove (int i, int j) throws IOException;

  /**
   * Remove all data from the cache.
   */
  public void clear () throws IOException;

  /**
   * Close the cache.
   */
  public void close () throws IOException;
}
```

If you implement this interface with your own class, your application code must instantiate your class and then use the `setResultSetCache()` method of an `OracleStatement`, `OraclePreparedStatement`, or `OracleCallableStatement` object to set the caching mechanism to use your implementation. Following is the method signature:

- `void setResultSetCache(OracleResultSetCache cache)`
  `throws SQLException`

Call this method prior to executing a query. The result set produced by the query will then use your specified caching mechanism.

Creating Scrollable or Updatable Result Sets

In using JDBC 2.0 result set enhancements, you may specify the result set type (for scrollability and sensitivity) and the concurrency type (for updatability) when you create a generic statement or prepare a prepared statement or callable statement that will execute a query.

(Note, however, that callable statements are intended to execute stored procedures and functions and rarely return a result set. Still, the callable statement class is a subclass of the prepared statement class and so inherits this functionality.)

This section discusses the creation of result sets to use JDBC 2.0 enhancements.

Specifying Result Set Scrollability and Updatability

Under JDBC 2.0, `Connection` classes have `createStatement()`, `prepareStatement()`, and `prepareCall()` method signatures that take a result set type and a concurrency type as input:

- `Statement createStatement`
  `(int resultSetType, int resultSetConcurrency)`
- `PreparedStatement prepareStatement`
  `(String sql, int resultSetType, int resultSetConcurrency)`
- `CallableStatement prepareCall`
  `(String sql, int resultSetType, int resultSetConcurrency)`

The statement objects created will have the intelligence to produce the appropriate kind of result sets.

You can specify one of the following static constant values for result set type:

- `ResultSet.TYPE_FORWARD_ONLY`
- `ResultSet.TYPE_SCROLL_INSENSITIVE`
- `ResultSet.TYPE_SCROLL_SENSITIVE`

> **Note:** See "Oracle Implementation of Scroll-Sensitive Result Sets" on page 17-20 for information about possible performance impact.

And you can specify one of the following static constant values for concurrency type:

- `ResultSet.CONCUR_READ_ONLY`
- `ResultSet.CONCUR_UPDATABLE`

After creating a `Statement`, `PreparedStatement`, or `CallableStatement` object, you can verify its result set type and concurrency type by calling the following methods on the statement object:

- `int getResultSetType() throws SQLException`
- `int getResultSetConcurrency() throws SQLException`

Example 17–1 Prepared Statement Object With Result Set

Following is an example of a prepared statement object that specifies a scroll-sensitive and updatable result set for queries executed through that statement (where `conn` is a connection object):

```
...
PreparedStatement pstmt = conn.prepareStatement
  ("SELECT empno, sal FROM emp WHERE empno = ?",
  ResultSet.TYPE_SCROLL_SENSITIVE, ResultSet.CONCUR_UPDATABLE);

pstmt.setString(1, "28959");
ResultSet rs = pstmt.executeQuery();
...
```

Result Set Limitations and Downgrade Rules

Some types of result sets are not feasible for certain kinds of queries. If you specify an unfeasible result set type or concurrency type for the query you execute, the JDBC driver follows a set of rules to determine the best feasible types to use instead.

The actual result set type and concurrency type are determined when the statement is executed, with the driver issuing a `SQLWarning` on the statement object if the desired result set type or concurrency type is not feasible. The `SQLWarning` object will contain the reason why the requested type was not feasible. Check for warnings to verify whether you received the type of result set that you requested, or call the methods described in "Verifying Result Set Type and Concurrency Type" on page 17-8.

Result Set Limitations

The following limitations are placed on queries for enhanced result sets. Failure to follow these guidelines will result in the JDBC driver choosing an alternative result set type or concurrency type.

To produce an updatable result set:

- A query can select from only a single table and cannot contain any join operations.

  In addition, for inserts to be feasible, the query must select all non-nullable columns and all columns that do not have a default value.
- A query cannot use "`SELECT *`". (But see the workaround below.)
- A query must select table columns only. It cannot select derived columns or aggregates such as the `SUM` or `MAX` of a set of columns.

To produce a scroll-sensitive result set:

- A query cannot use "`SELECT *`". (But see the workaround below.)
- A query can select from only a single table.

(See "Summary of New Methods for Result Set Enhancements" on page 17-21 for general information about refetching.)

Workaround As a workaround for the "`SELECT *`" limitation, you can use table aliases as in the following example:

```
SELECT t.* FROM TABLE t ...
```

> **Hint:** There is a simple way to determine if your query will probably produce a scroll-sensitive or updatable result set: If you can legally add a ROWID column to the query list, then the query is probably suitable for either a scroll-sensitive or an updatable result set. (You can try this out using SQL*Plus, for example.)

Result Set Downgrade Rules

If the specified result set type or concurrency type is not feasible, the Oracle JDBC driver uses the following rules in choosing alternate types:

- If the specified result set type is `TYPE_SCROLL_SENSITIVE`, but the JDBC driver cannot fulfill that request, then the driver attempts a downgrade to `TYPE_SCROLL_INSENSITIVE`.
- If the specified (or downgraded) result set type is `TYPE_SCROLL_INSENSITIVE`, but the JDBC driver cannot fulfill that request, then the driver attempts a downgrade to `TYPE_FORWARD_ONLY`.

Furthermore:

- If the specified concurrency type is `CONCUR_UPDATABLE`, but the JDBC driver cannot fulfill that request, then the JDBC driver attempts a downgrade to `CONCUR_READ_ONLY`.

> **Notes:**
>
> - Criteria that would prevent the JDBC driver from fulfilling the result set type specifications are listed in "Result Set Limitations" on page 17-6.
> - Any manipulations of the result set type and concurrency type by the JDBC driver are independent of each other.

Verifying Result Set Type and Concurrency Type

After a query has been executed, you can verify the result set type and concurrency type that the JDBC driver actually used, by calling methods on the result set object.

- `int getType() throws SQLException`

  This method returns an `int` value for the result set type used for the query. `ResultSet.TYPE_FORWARD_ONLY`, `ResultSet.TYPE_SCROLL_SENSITIVE`, or `ResultSet.TYPE_SCROLL_INSENSITIVE` are the possible values.

- `int getConcurrency() throws SQLException`

  This method returns an `int` value for the concurrency type used for the query. `ResultSet.CONCUR_READ_ONLY` or `ResultSet.CONCUR_UPDATABLE` are the possible values.

Positioning and Processing in Scrollable Result Sets

Scrollable result sets (result set type `TYPE_SCROLL_SENSITIVE` or `TYPE_SCROLL_INSENSITIVE`) allow you to iterate through, them either forward or backward, and to position the result set to any desired row.

This section discusses positioning within a scrollable result set and how to process a scrollable result set backward, instead of forward.

Positioning in a Scrollable Result Set

In a scrollable result set, you can use several result set methods to move to a desired position and to check the current position.

Methods for Moving to a New Position

The following result set methods are available for moving to a new position in a scrollable result set:

- `void beforeFirst() throws SQLException`
- `void afterLast() throws SQLException`
- `boolean first() throws SQLException`
- `boolean last() throws SQLException`
- `boolean absolute(int row) throws SQLException`
- `boolean relative(int row) throws SQLException`

> **Note:** You cannot position a forward-only result set. Any attempt to position it or to determine the current position will result in a `SQLException`.

beforeFirst() Method Positions to before the first row of the result set, or has no effect if there are no rows in the result set.

This is where you would typically start iterating through a result set to process it going forward, and is the default initial position for any kind of result set.

You are outside the result set bounds after a `beforeFirst()` call. There is no valid current row, and you cannot position relatively from this point.

afterLast() Method Positions to after the last row of the result set, or has no effect if there are no rows in the result set.

This is where you would typically start iterating through a result set to process it going backward.

You are outside the result set bounds after an `afterLast()` call. There is no valid current row, and you cannot position relatively from this point.

first() Method Positions to the first row of the result set, or returns `false` if there are no rows in the result set.

last() Method Positions to the last row of the result set, or returns `false` if there are no rows in the result set.

absolute() Method Positions to an absolute row from either the beginning or end of the result set. If you input a positive number, it positions from the beginning; if you input a negative number, it positions from the end. This method returns `false` if there are no rows in the result set.

Attempting to move forward beyond the last row, such as an `absolute(11)` call if there are 10 rows, will position to after the last row, having the same effect as an `afterLast()` call.

Attempting to move backward beyond the first row, such as an `absolute(-11)` call if there are 10 rows, will position to before the first row, having the same effect as a `beforeFirst()` call.

Note: Calling `absolute(1)` is equivalent to calling `first()`; calling `absolute(-1)` is equivalent to calling `last()`.

---

relative() Method Moves to a position relative to the current row, either forward if you input a positive number or backward if you input a negative number, or returns `false` if there are no rows in the result set.

The result set must be at a valid current row for use of the `relative()` method.

Attempting to move forward beyond the last row will position to after the last row, having the same effect as an `afterLast()` call.

Attempting to move backward beyond the first row will position to before the first row, having the same effect as a `beforeFirst()` call.

A `relative(0)` call is valid but has no effect.

Important: You cannot position relatively from before the first row (which is the default initial position) or after the last row. Attempting relative positioning from either of these positions would result in a `SQLException`.

Methods for Checking the Current Position

The following result set methods are available for checking the current position in a scrollable result set:

- `boolean isBeforeFirst() throws SQLException`

  Returns `true` if the position is before the first row.

- `boolean isAfterLast() throws SQLException`

  Returns `true` if the position is after the last row.

- `boolean isFirst() throws SQLException`

  Returns `true` if the position is at the first row.

- `boolean isLast() throws SQLException`

  Returns `true` if the position is at the last row.

- `int getRow() throws SQLException`

  Returns the row number of the current row, or returns 0 if there is no valid current row.

> **Note:** The boolean methods—`isFirst()`, `isLast()`, `isAfterFirst()`, and `isAfterLast()`—all return `false` (and do *not* throw an exception) if there are no rows in the result set.

Processing a Scrollable Result Set

In a scrollable result set you can iterate backward instead of forward as you process the result set. The following methods are available:

- `boolean next() throws SQLException`
- `boolean previous() throws SQLException`

The `previous()` method works similarly to the `next()` method, in that it returns `true` as long as the new current row is valid, and `false` as soon as it runs out of rows (has passed the first row).

Backward versus Forward Processing

You can process the entire result set going forward, using the `next()` method. This is documented in "Processing the Result Set" on page 4-9. The default initial position in the result set is before the first row, appropriately, but you can call the `beforeFirst()` method if you have moved elsewhere since the result set was created.

To process the entire result set going backward, call `afterLast()`, then use the `previous()` method. For example (where `conn` is a connection object):

```
...
/* NOTE: The specified concurrency type, CONCUR_UPDATABLE, is not relevant to this
example. */

Statement stmt = conn.createStatement
         (ResultSet.TYPE_SCROLL_SENSITIVE, ResultSet.CONCUR_UPDATABLE);

ResultSet rs = stmt.executeQuery("SELECT empno, sal FROM emp");

rs.afterLast();
```

```
while (rs.previous())
{
   System.out.println(rs.getString("empno") + " " + rs.getFloat("sal"));
}
...
```

Unlike relative positioning, you can (and typically do) use `next()` from before the first row and `previous()` from after the last row. You do not have to be at a valid current row to use these methods.

> **Note:** In a non-scrollable result set, you can process only with the `next()` method. Attempting to use the `previous()` method will cause a `SQLException`.

Presetting the Fetch Direction

The JDBC 2.0 standard allows the ability to pre-specify the direction, known as the *fetch direction*, for use in processing a result set. This allows the JDBC driver to optimize its processing. The following result set methods are specified:

- `void setFetchDirection(int direction) throws SQLException`
- `int getFetchDirection() throws SQLException`

The Oracle JDBC drivers support only the forward preset value, which you can specify by inputting the `ResultSet.FETCH_FORWARD` static constant value.

The values `ResultSet.FETCH_REVERSE` and `ResultSet.FETCH_UNKNOWN` are not supported—attempting to specify them causes a SQL warning, and the settings are ignored.

Updating Result Sets

A concurrency type of `CONCUR_UPDATABLE` allows you to update rows in the result set, delete rows from the result set, or insert rows into the result set.

After you perform an `UPDATE` or `INSERT` operation in a result set, you propagate the changes to the database in a separate step that you can skip if you want to cancel the changes.

A `DELETE` operation in a result set, however, is immediately executed (but not necessarily committed) in the database as well.

> **Note:** When using an updatable result set, it is typical to also make it scrollable. This allows you to position to any row that you want to change. With a forward-only updatable result set, you can change rows only as you iterate through them with the `next()` method.

Performing a DELETE Operation in a Result Set

The result set `deleteRow()` method will delete the current row. Following is the method signature:

- `void deleteRow() throws SQLException`

> **Important:** Unlike `UPDATE` and `INSERT` operations in a result set, which require a separate step to propagate the changes to the database, a `DELETE` operation in a result set is immediately executed in the corresponding row in the database as well.
>
> Once you call `deleteRow()`, the changes will be made permanent with the next transaction `COMMIT` operation. Remember also that by default, the auto-commit flag is set to `true`. Therefore, unless you override this default, any `deleteRow()` operation will be executed and committed immediately.

Presuming the result set is also scrollable, you can position to a row using any of the available positioning methods (except `beforeFirst()` and `afterLast()`, which do not go to a valid current row), and then delete that row, as in the following example (presuming a result set `rs`):

```
...
rs.absolute(5);
rs.deleteRow();
...
```

See "Positioning in a Scrollable Result Set" on page 17-8 for information about the positioning methods.

> **Important:** The deleted row remains in the result set object even after it has been deleted from the database.
>
> In a scrollable result set, by contrast, a `DELETE` operation is evident in the local result set object—the row would no longer be in the result set after the `DELETE`. The row preceding the deleted row becomes the current row, and row numbers of subsequent rows are changed accordingly.
>
> Refer to "Seeing Internal Changes" on page 17-18 for more information.

Performing an UPDATE Operation in a Result Set

Performing a result set `UPDATE` operation requires two separate steps to first update the data in the result set and then copy the changes to the database.

Presuming the result set is also scrollable, you can position to a row using any of the available positioning methods (except `beforeFirst()` and `afterLast()`, which do not go to a valid current row), and then update that row as desired.

See "Positioning in a Scrollable Result Set" on page 17-8 for information about the positioning methods.

Here are the steps for updating a row in the result set and database:

1. Call the appropriate `updateXXX()` methods to update the data in the columns you want to change.

With JDBC 2.0, a result set object has an `updateXXX()` method for each datatype, as with the `setXXX()` methods previously available for updating the database directly.

Each of these methods takes an `int` for the column number or a string for the column name and then an item of the appropriate datatype to set the new value. Following are a couple of examples for a result set `rs`:

```
rs.updateString(1, "mystring");
rs.updateFloat(2, 10000.0f);
```

2. Call the `updateRow()` method to copy the changes to the database (or the `cancelRowUpdates()` method to cancel the changes).

   Once you call `updateRow()`, the changes are executed and will be made permanent with the next transaction `COMMIT` operation. Be aware that by default, the auto-commit flag is set to `true` so that any executed operation is committed immediately.

   If you choose to cancel the changes before copying them to the database, call the `cancelRowUpdates()` method instead. This will also revert to the original values for that row in the local result set object. Note that once you call the `updateRow()` method, the changes are written to the transaction and cannot be canceled unless you roll back the transaction (auto-commit must be disabled to allow a `ROLLBACK` operation).

   Positioning to a different row before calling `updateRow()` also cancels the changes and reverts to the original values in the result set.

   Before calling `updateRow()`, you can call the usual `getXXX()` methods to verify that the values have been updated correctly. These methods take an `int` column index or string column name as input. For example:

```
float myfloat = rs.getFloat(2);
...process myfloat to see if it's appropriate...
```

> **Note:** Result set `UPDATE` operations are visible in the local result set object for all result set types (forward-only, scroll-sensitive, and scroll-insensitive).
>
> Refer to "Seeing Internal Changes" on page 17-18 for more information.

Example

Following is an example of a result set `UPDATE` operation that is also copied to the database. The tenth row is updated. (The column number is used to specify column 1, and the column name—`sal`— is used to specify column 2.)

```
Statement stmt = conn.createStatement
         (ResultSet.TYPE_SCROLL_SENSITIVE, ResultSet.CONCUR_UPDATABLE);
ResultSet rs = stmt.executeQuery("SELECT empno, sal FROM emp");
if (rs.absolute(10))        // (returns false if row does not exist)
{
   rs.updateString(1, "28959");
   rs.updateFloat("sal", 100000.0f);
   rs.updateRow();
}
// Changes are made permanent with the next COMMIT operation.
```

Performing an INSERT Operation in a Result Set

Result set `INSERT` operations use what is called the result set *insert-row*, which is a staging area that holds the data for the inserted row until it is copied to the database. You must explicitly move to this row to write the data that will be inserted.

As with `UPDATE` operations, result set `INSERT` operations require separate steps to first write the data to the insert-row and then copy it to the database.

Following are the steps in executing a result set `INSERT` operation.

1. Move to the insert-row by calling the result set `moveToInsertRow()` method.

   Note: The result set will remember the current position prior to the `moveToInsertRow()` call. Afterward, you can go back to it with a `moveToCurrentRow()` call.

2. As with `UPDATE` operations, use the appropriate `updateXXX()` methods to write data to the columns. For example:

   ```
   rs.updateString(1, "mystring");
   rs.updateFloat(2, 10000.0f);
   ```

   (Note that you can specify a string for column name, instead of an integer for column number.)

   Important: Each column value in the insert-row is undefined until you call the `updateXXX()` method for that column. You must call this method and specify a non-null value for all non-nullable columns, or else attempting to copy the row into the database will result in a `SQLException`.

   It is permissible, however, to *not* call `updateXXX()` for a nullable column. This will result in a value of `null`.

3. Copy the changes to the database by calling the result set `insertRow()` method.

   Once you call `insertRow()`, the insert is executed and will be made permanent with the next transaction `COMMIT` operation.

   Positioning to a different row before calling `insertRow()` cancels the insert and clears the insert-row.

   Before calling `insertRow()` you can call the usual `getXXX()` methods to verify that the values have been set correctly in the insert-row. These methods take an `int` column index or string column name as input. For example:

   ```
   float myfloat = rs.getFloat(2);
   ...process myfloat to see if it's appropriate...
   ```

   Note: No result set type (neither scroll-sensitive, scroll-insensitive, nor forward-only) can see a row inserted by a result set `INSERT` operation.

   Refer to "Seeing Internal Changes" on page 17-18 for more information.

Example

The following example performs a result set `INSERT` operation, moving to the insert-row, writing the data, copying the data into the database, and then returning to what was the current row prior to going to the insert-row. (The column number is used to specify column 1, and the column name—`sal`— is used to specify column 2.)

```
...
Statement stmt = conn.createStatement
         (ResultSet.TYPE_SCROLL_SENSITIVE, ResultSet.CONCUR_UPDATABLE);

ResultSet rs = stmt.executeQuery("SELECT empno, sal FROM emp");

rs.moveToInsertRow();
rs.updateString(1, "28959");
rs.updateFloat("sal", 100000.0f);
rs.insertRow();
// Changes will be made permanent with the next COMMIT operation.
rs.moveToCurrentRow();  // Go back to where we came from...
...
```

Update Conflicts

It is important to be aware of the following facts regarding updatable result sets with the JDBC drivers:

- The drivers do not enforce write locks for an updatable result set.
- The drivers do not check for conflicts with a result set `DELETE` or `UPDATE` operation.

A conflict will occur if you try to perform a `DELETE` or `UPDATE` operation on a row updated by another committed transaction.

The Oracle JDBC drivers use the ROWID to uniquely identify a row in a database table. As long as the ROWID is still valid when a driver tries to send an `UPDATE` or `DELETE` operation to the database, the operation will be executed.

The driver will not report any changes made by another committed transaction. Any conflicts are silently ignored and your changes will overwrite the previous changes.

To avoid such conflicts, use the Oracle `FOR UPDATE` feature when executing the query that produces the result set. This will avoid conflicts, but will also prevent simultaneous access to the data. Only a single write lock can be held concurrently on a data item.

Fetch Size

By default, when Oracle JDBC executes a query, it receives the result set 10 rows at a time from the database cursor. This is the default Oracle *row-prefetch value*. You can change the number of rows retrieved with each trip to the database cursor by changing the row-prefetch value (see "Oracle Row Prefetching" on page 22-15 for more information).

JDBC 2.0 also allows you to specify the number of rows fetched with each database round trip for a query, and this number is referred to as the *fetch size*. In Oracle JDBC, the row-prefetch value is used as the default fetch size in a statement object. Setting the fetch size overrides the row-prefetch setting and affects subsequent queries executed through that statement object.

Fetch size is also used in a result set. When the statement object executes a query, the fetch size of the statement object is passed to the result set object produced by the query. However, you can also set the fetch size in the result set object to override the statement fetch size that was passed to it. (Also note that changes made to a statement object's fetch size after a result set is produced will have no affect on that result set.)

The result set fetch size, either set explicitly, or by default equal to the statement fetch size that was passed to it, determines the number of rows that are retrieved in any subsequent trips to the database for that result set. This includes any trips that are still required to complete the original query, as well as any *refetching* of data into the result set. (Data can be refetched, either explicitly or implicitly, to update a scroll-sensitive or scroll-insensitive/updatable result set. See "Refetching Rows" on page 17-16.)

Setting the Fetch Size

The following methods are available in all `Statement`, `PreparedStatement`, `CallableStatement`, and `ResultSet` objects for setting and getting the fetch size:

- `void setFetchSize(int rows) throws SQLException`
- `int getFetchSize() throws SQLException`

To set the fetch size for a query, call `setFetchSize()` on the statement object prior to executing the query. If you set the fetch size to N, then N rows are fetched with each trip to the database.

After you have executed the query, you can call `setFetchSize()` on the result set object to override the statement object fetch size that was passed to it. This will affect any subsequent trips to the database to get more rows for the original query, as well as affecting any later refetching of rows. (See "Refetching Rows" on page 17-16.)

Use of Standard Fetch Size versus Oracle Row-Prefetch Setting

Using the JDBC 2.0 fetch size is fundamentally similar to using the Oracle row-prefetch value, except that with the row-prefetch value you do not have the flexibility of distinct values in the statement object and result set object. The row prefetch value would be used everywhere.

Furthermore, JDBC 2.0 fetch size usage is portable and can be used with other JDBC drivers. Oracle row-prefetch usage is vendor-specific.

See "Oracle Row Prefetching" on page 22-15 for a general discussion of this Oracle feature.

Note: Do not mix the JDBC 2.0 fetch size API and the Oracle row prefetching API in your application. You can use one or the other, but not both.

Refetching Rows

The result set `refreshRow()` method is supported for some types of result sets for *refetching* data. This consists of going back to the database to re-obtain the database rows that correspond to N rows in the result set, starting with the current row, where N is the fetch size (described above in "Fetch Size" on page 17-15). This lets you see the latest updates to the database that were made outside of your result set, subject to the isolation level of the enclosing transaction.

Because refetching re-obtains only rows that correspond to rows already in your result set, it does nothing about rows that have been inserted or deleted in the database since the original query. It ignores rows that have been inserted, and rows will remain in your result set even after the corresponding rows have been deleted from the database. When there is an attempt to refetch a row that has been deleted in the database, the corresponding row in the result set will maintain its original values.

Following is the `refreshRow()` method signature:

- `void refreshRow() throws SQLException`

You must be at a valid current row when you call this method, not outside the row bounds and not at the insert-row.

The `refreshRow()` method is supported for the following result set categories:

- scroll-sensitive/read-only
- scroll-sensitive/updatable
- scroll-insensitive/updatable

Oracle JDBC might support additional result set categories in future releases.

> **Note:** Scroll-sensitive result set functionality is implemented through implicit calls to `refreshRow()`. See "Oracle Implementation of Scroll-Sensitive Result Sets" on page 17-20 for details.

Seeing Database Changes Made Internally and Externally

This section discusses the ability of a result set to see the following:

- its own changes (`DELETE`, `UPDATE`, or `INSERT` operations within the result set), referred to as *internal changes*
- changes made from elsewhere (either from your own transaction outside the result set, or from other committed transactions), referred to as *external changes*

Near the end of the section is a summary table.

> **Note:** External changes are referred to as "other's changes" in the Sun Microsystems JDBC 2.0 specification.

Seeing Internal Changes

The ability of an updatable result set to see its own changes depends on both the result set type and the kind of change (`UPDATE`, `DELETE`, or `INSERT`). This is discussed at various points throughout the "Updating Result Sets" section beginning on on page 17-11, and is summarized as follows:

- Internal `DELETE` operations are visible for scrollable result sets (scroll-sensitive or scroll-insensitive), but are not visible for forward-only result sets.

  After you delete a row in a scrollable result set, the preceding row becomes the new current row, and subsequent row numbers are updated accordingly.
- Internal `UPDATE` operations are always visible, regardless of the result set type (forward-only, scroll-sensitive, or scroll-insensitive).
- Internal `INSERT` operations are never visible, regardless of the result set type (neither forward-only, scroll-sensitive, nor scroll-insensitive).

An internal change being "visible" essentially means that a subsequent `getXXX()` call will see the data changed by a preceding `updateXXX()` call on the same data item.

JDBC 2.0 `DatabaseMetaData` objects include the following methods to verify this. Each takes a result set type as input (`ResultSet.TYPE_FORWARD_ONLY`, `ResultSet.TYPE_SCROLL_SENSITIVE`, or `ResultSet.TYPE_SCROLL_INSENSITIVE`).

- `boolean ownDeletesAreVisible(int) throws SQLException`
- `boolean ownUpdatesAreVisible(int) throws SQLException`
- `boolean ownInsertsAreVisible(int) throws SQLException`

> **Note:** When you make an internal change that causes a trigger to execute, the trigger changes are effectively external changes. However, if the trigger affects data in the row you are updating, you *will* see those changes for any scrollable/updatable result set, because an implicit row refetch occurs after the update.

Seeing External Changes

Only a scroll-sensitive result set can see external changes to the underlying database, and it can only see the changes from external `UPDATE` operations. Changes from external `DELETE or INSERT` operations are never visible.

> **Note:** Any discussion of seeing changes from outside the enclosing transaction presumes the transaction itself has an isolation level setting that allows the changes to be visible.

For implementation details of scroll-sensitive result sets, including exactly how and how soon external updates become visible, see "Oracle Implementation of Scroll-Sensitive Result Sets" on page 17-20.

JDBC 2.0 `DatabaseMetaData` objects include the following methods to verify this. Each takes a result set type as input (`ResultSet.TYPE_FORWARD_ONLY`, `ResultSet.TYPE_SCROLL_SENSITIVE`, or `ResultSet.TYPE_SCROLL_INSENSITIVE`).

- `boolean othersDeletesAreVisible(int) throws SQLException`
- `boolean othersUpdatesAreVisible(int) throws SQLException`
- `boolean othersInsertsAreVisible(int) throws SQLException`

> **Note:** Explicit use of the `refreshRow()` method, described in "Refetching Rows" on page 17-16, is distinct from this discussion of visibility. For example, even though external updates are "invisible" to a scroll-insensitive result set, you can explicitly refetch rows in a scroll-insensitive/updatable result set and retrieve external changes that have been made. "Visibility" refers only to the fact that the scroll-insensitive/updatable result set would not see such changes automatically and implicitly.

Visibility versus Detection of External Changes

Regarding changes made to the underlying database by external sources, there are two similar but distinct concepts with respect to visibility of the changes from your local result set:

- visibility of changes
- detection of changes

A change being "visible" means that when you look at a row in the result set, you can see new data values from changes made by external sources to the corresponding row in the database.

A change being "detected", however, means that the result set is *aware* that this is a new value since the result set was first populated.

Even when an Oracle result set sees new data (as with an external `UPDATE` in a scroll-sensitive result set), it has no awareness that this data has changed since the result set was populated. Such changes are not "detected".

JDBC 2.0 `DatabaseMetaData` objects include the following methods to verify this. Each takes a result set type as input (`ResultSet.TYPE_FORWARD_ONLY`, `ResultSet.TYPE_SCROLL_SENSITIVE`, or `ResultSet.TYPE_SCROLL_INSENSITIVE`).

- `boolean deletesAreDetected(int) throws SQLException`
- `boolean updatesAreDetected(int) throws SQLException`
- `boolean insertsAreDetected(int) throws SQLException`

It follows, then, that result set methods specified by JDBC 2.0 to detect changes—`rowDeleted()`, `rowUpdated()`, and `rowInserted()`—will always return false. There is no use in calling them.

Summary of Visibility of Internal and External Changes

Table 17–1 summarizes the discussion in the preceding sections regarding whether a result set object in the Oracle JDBC implementation can see changes made internally through the result set itself, and changes made externally to the underlying database from elsewhere in your transaction or from other committed transactions.

Table 17–1 Visibility of Internal and External Changes for Oracle JDBC

Result Set Type	Can See Internal DELETE?	Can See Internal UPDATE?	Can See Internal INSERT?	Can See External DELETE?	Can See External UPDATE?	Can See External INSERT?
forward-only	no	yes	no	no	no	no
scroll-sensitive	yes	yes	no	no	yes	no
scroll-insensitive	yes	yes	no	no	no	no

For implementation details of scroll-sensitive result sets, including exactly how and how soon external updates become visible, see "Oracle Implementation of Scroll-Sensitive Result Sets" on page 17-20.

Notes:

- Remember that explicit use of the `refreshRow()` method, described in "Refetching Rows" on page 17-16, is distinct from the concept of "visibility" of external changes. This is discussed in "Seeing External Changes" on page 17-18.
- Remember that even when external changes are "visible", as with `UPDATE` operations underlying a scroll-sensitive result set, they are not "detected". The result set `rowDeleted()`, `rowUpdated()`, and `rowInserted()` methods always return `false`. This is further discussed in "Visibility versus Detection of External Changes" on page 17-19.

Oracle Implementation of Scroll-Sensitive Result Sets

The Oracle implementation of scroll-sensitive result sets involves the concept of a *window*, with a window size that is based on the fetch size. The window size affects how often rows are updated in the result set.

Once you establish a current row by moving to a specified row (as described in "Positioning in a Scrollable Result Set" on page 17-8), the window consists of the N rows in the result set starting with that row, where N is the fetch size being used by the result set (see "Fetch Size" on page 17-15). Note that there is no current row, and therefore no window, when a result set is first created. The default position is before the first row, which is not a valid current row.

As you move from row to row, the window remains unchanged as long as the current row stays within that window. However, once you move to a new current row outside the window, you redefine the window to be the N rows starting with the new current row.

Whenever the window is redefined, the N rows in the database corresponding to the rows in the new window are automatically refetched through an implicit call to the `refreshRow()` method (described in "Refetching Rows" on page 17-16), thereby updating the data throughout the new window.

So external updates are not instantaneously visible in a scroll-sensitive result set; they are only visible after the automatic refetches just described.

> **Note:** Because this kind of refetching is not a highly efficient or optimized methodology, there are significant performance concerns. Consider carefully before using scroll-sensitive result sets as currently implemented. There is also a significant trade-off between sensitivity and performance. The most sensitive result set is one with a fetch size of 1, which would result in the new current row being refetched every time you move between rows. However, this would have a significant impact on the performance of your application.

Summary of New Methods for Result Set Enhancements

This section summarizes all the new connection, result set, statement, and database meta data methods added for JDBC 2.0 result set enhancements. These methods are more fully discussed throughout this chapter.

Modified Connection Methods

Following is an alphabetical summary of modified connection methods that allow you to specify result set and concurrency types when you create statement objects.

- `Statement createStatement (int resultSetType, int resultSetConcurrency)`

  This method now allows you to specify result set type and concurrency type when you create a generic `Statement` object.

- `CallableStatement prepareCall (String sql, int resultSetType, int resultSetConcurrency)`

  This method now allows you to specify result set type and concurrency type when you create a `PreparedStatement` object.

- `PreparedStatement prepareStatement (String sql, int resultSetType, int resultSetConcurrency)`

  This method now allows you to specify result set type and concurrency type when you create a `CallableStatement` object.

New Result Set Methods

Following is an alphabetical summary of new result set methods for JDBC 2.0 result set enhancements.

- `boolean absolute(int row) throws SQLException`

  Move to an absolute row position in the result set.

- `void afterLast() throws SQLException`

  Move to after the last row in the result set (you will not be at a valid current row after this call).

- `void beforeFirst() throws SQLException`

  Move to before the first row in the result set (you will not be at a valid current row after this call).

- `void cancelRowUpdates() throws SQLException`

  Cancel an `UPDATE` operation on the current row. (Call this after the `updateXXX()` calls but before the `updateRow()` call.)

- `void deleteRow() throws SQLException`

  Delete the current row.

- `boolean first() throws SQLException`

  Move to the first row in the result set.

- `int getConcurrency() throws SQLException`

  Returns an `int` value for the concurrency type used for the query (either `ResultSet.CONCUR_READ_ONLY` or `ResultSet.CONCUR_UPDATABLE`).

- `int getFetchSize() throws SQLException`

  Check the fetch size to determine how many rows are fetched in each database round trip (also available in statement objects).

- `int getRow() throws SQLException`

  Returns the row number of the current row. Returns 0 if there is no valid current row.

- `int getType() throws SQLException`

  Returns an `int` value for the result set type used for the query (either `ResultSet.TYPE_FORWARD_ONLY`, `ResultSet.TYPE_SCROLL_SENSITIVE`, or `ResultSet.TYPE_SCROLL_INSENSITIVE`).

- `void insertRow() throws SQLException`

  Write a result set `INSERT` operation to the database. Call this after calling `updateXXX()` methods to set the data values.

- `boolean isAfterLast() throws SQLException`

  Returns `true` if the position is after the last row.

- `boolean isBeforeFirst() throws SQLException`

  Returns `true` if the position is before the first row.

- `boolean isFirst() throws SQLException`

  Returns `true` if the position is at the first row.

- `boolean isLast() throws SQLException`

  Returns `true` if the position is at the last row.

- `boolean last() throws SQLException`

  Move to the last row in the result set.

- `void moveToCurrentRow() throws SQLException`

  Move from the insert-row staging area back to what had been the current row prior to the `moveToInsertRow()` call.

- `void moveToInsertRow() throws SQLException`

  Move to the insert-row staging area to set up a row to be inserted.

- `boolean next() throws SQLException`

  Iterate forward through the result set.

- `boolean previous() throws SQLException`

  Iterate backward through the result set.

- `void refreshRow() throws SQLException`

  Refetch the database rows corresponding to the current window in the result set, to update the data. This method is called implicitly for scroll-sensitive result sets.

- `boolean relative(int row) throws SQLException`

  Move to a relative row position, either forward or backward from the current row.

- `void setFetchSize(int rows) throws SQLException`

  Set the fetch size to determine how many rows are fetched in each database round trip when refetching (also available in statement objects).

- `void updateRow() throws SQLException`

  Write an `UPDATE` operation to the database after using `updateXXX()` methods to update the data values.

- `void updateXXX() throws SQLException`

  Set or update data values in a row to be updated or inserted. There is an `updateXXX()` method for each datatype. After calling all the appropriate `updateXXX()` methods for the columns to be updated or inserted, call `updateRow()` for an `UPDATE` operation or `insertRow()` for an `INSERT` operation.

Statement Methods

Following is an alphabetical summary of statement methods for JDBC 2.0 result set enhancements. These methods are available in generic statement, prepared statement, and callable statement objects.

- `int getFetchSize() throws SQLException`

  Check the fetch size to determine how many rows are fetched in each database round trip when executing a query (also available in result set objects).

- `void setFetchSize(int rows) throws SQLException`

  Set the fetch size to determine how many rows are fetched in each database round trip when executing a query (also available in result set objects).

- `void setResultSetCache(OracleResultSetCache cache) throws SQLException`

  Use your own client-side cache implementation for scrollable result sets. Create your own class that implements the `OracleResultSetCache` interface, then use the `setResultSetCache()` method to input an instance of this class to the statement object that will create the result set.

- `int getResultSetType() throws SQLException`

  Check the result set type of result sets produced by this statement object (which was specified when the statement object was created).

- `int getResultSetConcurrency() throws SQLException`

  Check the concurrency type of result sets produced by this statement object (which was specified when the statement object was created).

Database Meta Data Methods

Following is an alphabetical summary of database meta data methods for JDBC 2.0 result set enhancements.

- `boolean ownDeletesAreVisible(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can see the effect of its own internal `DELETE` operations.

- `boolean ownUpdatesAreVisible(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can see the effect of its own internal `UPDATE` operations.

- `boolean ownInsertsAreVisible(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can see the effect of its own internal `INSERT` operations.

- `boolean othersDeletesAreVisible(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can see the effect of an external `DELETE` operation in the database.

- `boolean othersUpdatesAreVisible(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can see the effect of an external `UPDATE` operation in the database.

- `boolean othersInsertsAreVisible(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can see the effect of an external `INSERT` operation in the database.

- `boolean deletesAreDetected(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can detect when an external `DELETE` operation occurs in the database. This method always returns `false`.

- `boolean updatesAreDetected(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can detect when an external `UPDATE` operation occurs in the database. This method always returns `false`.

- `boolean insertsAreDetected(int) throws SQLException`

  Returns `true` if, in this JDBC implementation, the specified result set type can detect when an external `INSERT` operation occurs in the database. This method always returns `false`.

18

Row Set

This chapter describes the following topics:

Introduction

A *row set* is an object which encapsulates a set of rows. These rows are accessible though the `javax.sql.RowSet` interface. This interface supports component models of development, like JavaBeans, and is part of JDBC optional package by JavaSoft.

Three kinds of row set are supported by JavaSoft:

- Cached row set
- JDBC row set
- Web row set

As of 10*g* Release 1 (10.1), the Oracle JDBC drivers now support Web row set.

The `RowSet` interface provides a set of properties which can be altered to access the data in the database through a single interface. It supports properties and events which forms the core of JavaBeans. It has various properties like connect string, user name, password, type of connection, the query string itself, and also the parameters passed to the query. The following code executes a simple query:

```
...
rowset.setUrl ("jdbc:oracle:oci:@");
rowset.setUsername ("SCOTT");
rowset.setPassword ("TIGER");
rowset.setCommand (
  "SELECT empno, ename, sal FROM emp WHERE empno = ?");

// empno of employee name "KING"
rowset.setInt (1, 7839);
...
```

In this example, the URL, user name, password, SQL query, and bind parameter required for the query are set as the command properties to retrieve the employee name and salary. Also, the row set would contain `empno`, `ename`, and `sal` for the employee with the `empno` as `7839` and whose name is `KING`.

Row Set Setup and Configuration

The classes for the row set feature are found in a separate archive, `ocrs12.jar`. This file is located in the `$ORACLE_HOME/jdbc` directory. To use row set, you need to include this archive in your `CLASSPATH`.

For Unix (sh), the command is:

```
CLASSPATH=$CLASSPATH:$ORACLE_HOME/jdbc/lib/ocrs12.jar
export CLASSPATH
```

For Windows, the command is:

```
set CLASSPATH=%CLASSPATH%;%ORACLE_HOME%\jdbc\lib\ocrs12.jar
```

This might also be set in the project properties in case you are using an IDE like JDeveloper.

Oracle row set implementations are in the `oracle.jdbc.rowset` package. Import this package to use any of the Oracle row set implementations.

`OracleCachedRowSet`, `OracleJDBCRowSet`, and `OracleWebRowset` classes all implement the `javax.sql.RowSet` interface, which extends `java.sql.ResultSet`. Row set not only provides the interfaces of result set, but also some of the properties of the `java.sql.Connection` and `java.sql.PreparedStatement` interfaces. Connections and prepared statements are totally abstracted by this interface. Both `OracleCachedRowSet` and `OracleWebRowSet` are serializable. They implement the `java.io.Serializable` interface, which enables them to be moved across the network or JVM sessions.

Runtime Properties for Row Set

Typically, static properties for the applications can be set for a row set at the development time and the rest of the properties which are dynamic (are dependent on runtime) can be set at the runtime. The static properties may include the connection URL, username, password, connection type, concurrency type of the row set, or the query itself. The runtime properties, like the bind parameters for the query, could be bound at runtime. Scenarios where the query itself is a dynamic property is also common.

Row Set Listener

The row set feature supports multiple listeners to be registered with the `RowSet` object. Listeners can be registered using the `addRowSetListener()` method and unregistered through the `removeRowSetListener()` method. A listener should implement the `javax.sql.RowSetListener` interface to register itself as the row set listener. Three types of events are supported by the `RowSet` interface:

1. `cursorMoved` event : Generated whenever there is a cursor movement, which occurs when the `next()` or `previous()` methods are called
2. `rowChanged` event : Generated when a new row is inserted, updated, or deleted from the row set

3. `rowsetChanged` event : Generated when the whole row set is created or changed

The following code shows the registration of a row set listener:

```
MyRowSetListener rowsetListener =
  new MyRowSetListener ();
// adding a rowset listener.
rowset.addRowSetListener (rowsetListener);


// implementation of a rowset listener
public class MyRowSetListener implements RowSetListener
{
  public void cursorMoved(RowSetEvent event)
  {
   // action on cursor movement
  }

  public void rowChanged(RowSetEvent event)
  {
    // action on change of row
  }

  public void rowSetChanged(RowSetEvent event)
  {
    // action on changing of rowset
  }
}// end of class MyRowSetListener
```

Applications which handle only a few events can implement only the required events by using the `OracleRowSetAdapter` class, which is an abstract class with empty implementation for all the event handling methods.

In the following code, only the `rowSetChanged` event is handled. The remaining events are not handled by the application.

```
rowset.addRowSetListener (new OracleRowSetAdapter ()
  {
     public void rowSetChanged(RowSetEvent event)
     {
       // your action for rowsetChanged
     }
  }
 );
```

Traversing Through the Rows

The `RowSet` interface provides various methods to traverse through the row, including `absolute()`, `beforeFirst()`, `afterLast()`, and so on. These methods are inherited directly from the `java.sql.ResultSet` interface. The `RowSet` interface could be used as a `ResultSet` interface for retrieval and updating of data. The `RowSet` interface provides an optional way to implement a scrolling and updatable result set if they are not provided by the result set implementation.

> **Note:** The scrollable properties of the `java.sql.ResultSet` interface are also provided by the Oracle implementation of `ResultSet`.

Cached Row Set

A *cached row set* is a row set implementation where the rows are cached and the row set does not maintain an active connection to the database. A cached row set is a serializable, disconnect row set, implementing the standard `javax.sql.RowSet` interface. `OracleCachedRowSet` is the Oracle implementation of `CachedRowSet`, and can interoperate with Sun's reference implementation.

In the following code, an `OracleCachedRowSet` object is created and the connection URL, username, password, and the SQL query for the row set is set as properties. The `RowSet` object is populated through the `execute` method. After the `execute` call, the `RowSet` object can be used as a `java.sql.ResultSet` object to retrieve, scroll, insert, delete, or update data.

```
...
RowSet rowset = new OracleCachedRowSet ();
rowset.setUrl ("jdbc:oracle:oci:@");
rowset.setUsername ("SCOTT");
rowset.setPassword ("TIGER");
rowset.setCommand ("SELECT empno, ename, sal FROM emp");
rowset.execute ();
while (rowset.next ())
{
  System.out.println ("empno: " +rowset.getInt (1));
  System.out.println ("ename: " +rowset.getString (2));
  System.out.println ("sal: "   +rowset.getInt (3));
}
...
```

To populate a `CachedRowSet` object with a query, complete the following steps:

1. Instantiate `OracleCachedRowSet`.
2. Set connection `Url`, `Username`, `Password`, connection type (optional), and the query string as properties for the `RowSet` object.

   Invoke the `execute()` method to populate the `RowSet` object. Invoking `execute()` executes the query set as a property on this row set.

```
OracleCachedRowSet rowset = new OracleCachedRowSet ();
  rowset.setUrl ("jdbc:oracle:oci:@");
  rowset.setUsername ("SCOTT");
  rowset.setPassword ("TIGER");
  rowset.setCommand ("SELECT empno, ename, sal FROM emp");
  rowset.execute ();
```

`CachedRowSet` can be populated with the existing `ResultSet` object, using the `populate()` method.

To populate a `CachedRowSet` object with an already available result set, complete the following steps:

1. Instantiate `OracleCachedRowSet`.
2. Pass the already available `ResultSet` object to the `populate()` method to populate the `RowSet` object.

```
// Executing a query to get the ResultSet object.
ResultSet rset = pstmt.executeQuery ();

OracleCachedRowSet rowset = new OracleCachedRowSet ();
// the obtained ResultSet object is passed to the
// populate method to populate the data in the
// rowset object.
```

```
rowset.populate (rset);
```

In the above example, a `ResultSet` object is obtained by executing a query and the retrieved `ResultSet` object is passed to the `populate()` method of the cached row set to populate the contents of the result set into cached row set.

All the interfaces provided by the `ResultSet` interface are implemented in `RowSet`. The following code shows how to scroll through a row set:

```
/**
 *  Scrolling forward, and printing the empno in
 *  the order in which it was fetched.
 */
// going to the first row of the rowset
rowset.beforeFirst ();
while (rowset.next ())
  System.out.println ("empno: " +rowset.getInt (1));
```

> **Note:** Connection properties like transaction isolation or the concurrency mode of the result set and the bind properties cannot be set in the case where a pre-existent `ResultSet` object is used to populate the `CachedRowSet` object, since the connection or result set on which the property applies would have already been created.

In the example above, the cursor position is initialized to the position before the first row of the row set by the `beforeFirst()` method. The rows are retrieved in forward direction using the `next()` method.

```
/**
 *  Scrolling backward, and printing the empno in
 *  the reverse order as it was fetched.
 */
//going to the last row of the rowset
rowset.afterLast ();
while (rowset.previous ())
  System.out.println ("empno: " +rowset.getInt (1));
```

In the above example, the cursor position is initialized to the position after the last row of the `RowSet`. The rows are retrieved in reverse direction using the `previous()` method of `RowSet`.

Inserting, updating, and deleting rows are supported by the row set feature as they are in the result set feature. The following code illustrates the insertion of a row at the fifth position of a row set:

```
/**
 * Inserting a row in the 5th position of the rowset.
 */
// moving the cursor to the 5th position in the rowset
if (rowset.absolute(5))
{
  rowset.moveToInsertRow ();
  rowset.updateInt (1, 193);
  rowset.updateString (2, "Ashok");
  rowset.updateInt (3, 7200);

  // inserting a row in the rowset
  rowset.insertRow ();
```

```
  // Synchronizing the data in RowSet with that in the
  // database.
  rowset.acceptChanges ();
}
```

In the above example, a call to the `absolute()` method with a parameter `5` takes the cursor to the fifth position of the `row set` and a call to the `moveToInsertRow()` method creates a place for the insertion of a new row into the row set. The `updateXXX()` methods are used to update the newly created row. When all the columns of the row are updated, the `insertRow()` is called to update the row set. The changes are committed through `acceptChanges()` method.

The following code shows how an `OracleCachedRowSet` object is serialized to a file and then retrieved:

```
// writing the serialized OracleCachedRowSet object
{
  FileOutputStream fileOutputStream =
     new FileOutputStream ("emp_tab.dmp");
  ObjectOutputStream ostream = new
    ObjectOutputStream (fileOutputStream);
  ostream.writeObject (rowset);
  ostream.close ();
  fileOutputStream.close ();
}

// reading the serialized OracleCachedRowSet object
{
  FileInputStream fileInputStream = new
     FileInputStream ("emp_tab.dmp");
  ObjectInputStream istream = new
     ObjectInputStream (fileInputStream);
  RowSet rowset1 = (RowSet) istream.readObject ();
  istream.close ();
  fileInputStream.close ();
}
```

In the above example, a `FileOutputStream` object is opened for a `emp_tab.dmp` file, and the populated `OracleCachedRowSet` object is written to the file using `ObjectOutputStream`. This is retrieved using `FileInputStream` and the `ObjectInputStream` objects.

`OracleCachedRowSet` takes care of the serialization of non-serializable form of data like `InputStream`, `OutputStream`, BLOBS and CLOBS. `OracleCachedRowSets` also implements meta data of its own, which could be obtained without any extra server roundtrip. The following code shows how you can obtain meta data for the row set:

```
ResultSetMetaData metaData = rowset.getMetaData ();
int maxCol = metaData.getColumnCount ();
for (int i = 1; i <= maxCol; ++i)
   System.out.println ("Column (" + i +") "
     +metaData.getColumnName (i));
```

The above example illustrates how to retrieve a `ResultSetMetaData` object and print the column names in the `RowSet`.

Since the `OracleCachedRowSet` class is serializable, it can be passed across a network or between JVMs, as done in Remote Method Invocation (RMI). Once the `OracleCachedRowSet` class is populated, it can move around any JVM, or any

environment which does not have JDBC drivers. Committing the data in the row set (through the `acceptChanges()` method) requires the presence of JDBC drivers.

The complete process of retrieving the data and populating it in the `OracleCachedRowSet` class is performed on the server and the populated row set is passed on to the client using suitable architectures like RMI or Enterprise Java Beans (EJB). The client would be able to perform all the operations like retrieving, scrolling, inserting, updating, and deleting on the row set without any connection to the database. Whenever data is committed to the database, the `acceptChanges()` method is called which synchronizes the data in the row set to that in the database. This method makes use of JDBC drivers which require the JVM environment to contain JDBC implementation. This architecture would be suitable for systems involving a Thin client like a Personal Digital Assistant (PDA) or a Network Computer (NC).

After populating the `CachedRowSet` object, it can be used as a `ResultSet` object or any other object which can be passed over the network using RMI or any other suitable architecture.

Some of the other key-features of cached row set are the following:

- Cloning a row set
- Creating a copy of a row set
- Creating a shared copy of a row set

CachedRowSet Constraints

All the constraints which apply to updatable result set are applicable here, except serialization, since `OracleCachedRowSet` is serializable. The SQL query has the following constraints:

- References only a single table in the database
- Contain no join operations
- Selects the primary key of the table it references

In addition, a SQL query should also satisfy the conditions below if inserts are to be performed:

- Selects all of the non-nullable columns in the underlying table
- Selects all columns that do not have a default value

> **Note:** The `CachedRowSet` cannot hold a large quantity of data since all the data is cached in memory. Oracle therefore recommends against using `OracleCachedRowSet` with queries that could potentially return a large volume of data.

Properties which apply to the connection cannot be set after populating the row set since the properties cannot be applied to the connection after retrieving the data from the same like, transaction isolation and concurrency mode of the result set.

JDBC Row Set

A *JDBC row set* is another row set implementation. It is a simple, non-serializable connected row set which provides JDBC interfaces in the form of a Bean interface. Any call to `JDBCRowSet` percolates directly to the JDBC interface. The usage of the JDBC interface is the same as any other row set implementation.

Table 18–1 shows how the `JDBCRowSet` interface differs from `CachedRowSet` interface.

Table 18–1 The JDBC and Cached Row Sets Compared

RowSet Type	Serializable	Connected to Database	Movable Across JVMs	Synchronization of data to database	Presence of JDBC Drivers
JDBC	No	Yes	No	No	Yes
Cached	Yes	No	Yes	Yes	No

The JDBC row set is a connected row set which has a live connection to the database and all the calls on the JDBC row set are percolated to the mapping call in JDBC connection, statement, or result set. A cached row set does not have any connection to the database open.

JDBC row set requires the presence of JDBC drivers where a cached row set does not require JDBC drivers during manipulation, but during population of the row set and the committing the changes of the row set.

The following code shows how a JDBC row set is used:

```
RowSet rowset = new OracleJDBCRowSet ();
rowset.setUrl ("java:oracle:oci:@");
rowset.setUsername ("SCOTT");
rowset.setPassword ("TIGER");
rowset.setCommand (
  "SELECT empno, ename, sal FROM emp");
rowset.execute ();
while (rowset.next ())
{
  System.out.println ("empno: " + rowset.getInt (1));
  System.out.println ("ename: "
    + rowset.getString (2));
  System.out.println ("sal: " + rowset.getInt (3));
}
```

In the above example, the connection URL, username, password, and the SQL query is set as the connection properties to the row set and the query is executed through the `execute()` method and the rows are retrieved and printed.

19

JDBC OCI Extensions

This chapter describes the following OCI driver-specific features:

- OCI Driver Connection Pooling
- OCI Driver Transparent Application Failover
- OCI HeteroRM XA
- Accessing PL/SQL Index-by Tables

OCI Driver Connection Pooling

OCI driver connection pooling functionality, provided by the `OracleOCIConnectionPool` class, is part of the JDBC client.

A JDBC application can have multiple pools at the same time. Multiple pools can correspond to multiple application servers, or pools to different datasources. The connection pooling provided by OCI allows applications to have many logical connections, all using a small set of physical connections. Each call on this logical connection will be routed on the physical connection that is available at that time.

Note: Use OCI connection pooling if you need session multiplexing. Otherwise, we recommend using the Implicit Connection Cache; see Chapter 7, "Implicit Connection Caching" for details.

OCI Driver Connection Pooling: Background

The Oracle JDBC OCI driver provides several transaction monitor capabilities, such as the fine-grained management of Oracle sessions and connections. It is possible for a high-end application server or transaction monitor to multiplex several sessions over fewer physical connections on a call-level basis, thereby achieving a high degree of scalability by pooling of connections and back-end Oracle server processes.

The connection pooling provided by the `OracleOCIConnectionPool` interface simplifies the Session/Connection separation interface hiding the management of the physical connection pool. The Oracle sessions are the `OracleOCIConnection` connection objects obtained from the `OracleOCIConnectionPool`. The connection pool itself is normally configured with a much smaller shared pool of physical connections, translating to a back-end server pool containing an identical number of dedicated server processes. Note that many more Oracle sessions can be multiplexed over this pool of fewer shared connections and back-end Oracle processes.

OCI Driver Connection Pooling and Shared Servers Compared

In some ways, what OCI driver connection pooling offers on the middle tier is similar to what shared server processes offer on the back-end. OCI driver connection pooling makes a dedicated server instance behave as an shared instance by managing the session multiplexing logic on the middle tier. Therefore, the pooling of dedicated server processes and incoming connections into the dedicated server processes is controlled by the OCI connection pool on the middle tier.

The main difference between OCI connection pooling and shared servers is that in case of shared servers, the connection from the client is normally to a dispatcher in the database instance. The dispatcher is responsible for directing the client request to an appropriate shared server. On the other hand, the physical connection from the OCI connection pool is established directly from the middle tier to the Oracle dedicated server process in the back-end server pool.

Note that OCI connection pool is mainly beneficial only if the middle tier is multi-threaded. Each thread could maintain a session to the database. The actual connections to the database are maintained by the `OracleOCIConnectionPool` and these connections (including the pool of dedicated database server processes) are shared among all the threads in the middle tier.

Defining an OCI Connection Pool

An OCI connection pool is created at the beginning of the application. Creating connections from a pool is quite similar to creating connections using the `OracleDataSource` class.

The `oracle.jdbc.pool.OracleOCIConnectionPool` class, which extends the `OracleDataSource` class, is used to create OCI connection pools. From an `OracleOCIConnectionPool` class instance, you can obtain logical connection objects. These connection objects are of the `OracleOCIConnection` class type. This class implements the `OracleConnection` interface. The `Statement` objects you create from the `OracleOCIConnection` class have the same fields and methods as `OracleStatement` objects you create from `OracleConnection` instances.

The following code shows header information for the `OracleOCIConnectionPool` class:

```
/*
   * @param us  ConnectionPool user-id.
   * @param p   ConnectionPool password
   * @param name  logical name of the pool. This needs to be one in the
   *                  tnsnames.ora configuration file.
     @param config (optional)  Properties of the pool, if the default does not
                suffice. Default connection configuration is min =1, max=1,
                incr=0
                  Please refer setPoolConfig for property names.

                 Since this is optional, pass null if the default configuration
                 suffices.

   * @return
   *
   * Notes: Choose a userid and password that can act as proxy for the users
   *        in the getProxyConnection() method.

            If config is null, then the following default values will take
            effect
            CONNPOOL_MIN_LIMIT = 1
```

```
            CONNPOOL_MAX_LIMIT = 1
            CONNPOOL_INCREMENT = 0

*/

public synchronized OracleOCIConnectionPool
  (String       user,    String   password,  String name, Properties config)
  throws SQLException

/*
 * This will use the user-id, password and connection pool name values set
   LATER using the methods setUser, setPassword, setConnectionPoolName.

 * @return
 *
 * Notes:

     No OracleOCIConnection objects can be created on
     this class unless the methods setUser, setPassword, setPoolConfig
     are invoked.
     When invoking the setUser, setPassword later, choose a userid and
     password that can act as proxy for the users
 *   in the getProxyConnection() method.
 */
  public synchronized OracleOCIConnectionPool ()
    throws SQLException
```

Importing the oracle.jdbc.pool and oracle.jdbc.oci Packages

Before you create an OCI connection pool, import the following to have Oracle OCI connection pooling functionality:

```
import oracle.jdbc.pool.*;
import oracle.jdbc.oci.*;
```

Creating an OCI Connection Pool

The following code show how you create an instance of the `OracleOCIConnectionPool` class called `cpool`:

```
OracleOCIConnectionPool cpool = new OracleOCIConnectionPool
    ("SCOTT", "TIGER", "jdbc:oracle:oci:@(description=(address=(host=
    myhost)(protocol=tcp)(port=1521))(connect_data=(INSTANCE_NAME=orcl)))",
    poolConfig);
```

`poolConfig` is a set of properties which specify the connection pool. If `poolConfig` is null, then the default values are used. For example, consider the following:

- `poolConfig.put (OracleOCIConnectionPool.CONNPOOL_MIN_LIMIT, "4");`
- `poolConfig.put (OracleOCIConnectionPool.CONNPOOL_MAX_LIMIT, "10");`
- `poolConfig.put (OracleOCIConnectionPool.CONNPOOL_INCREMENT, "2");`

As an alternative to the above constructor call, you can create an instance of the `OracleOCIConnectionPool` class using individual methods to specify the user, password, and connection string.

```
OracleOCIConnectionPool cpool = new OracleOCIConnectionPool ( );
cpool.setUser("SCOTT");
cpool.setPassword("TIGER");
cpool.setURL("jdbc:oracle:oci:@(description=(address=(host=
    myhost)(protocol=tcp)(port=1521))(connect_data=(INSTANCE_NAME=orcl)))");
cpool.setPoolConfig(poolConfig);  // In case you want to specify a different
                                  // configuration other than the default
                                  // values.
```

Setting the OCI Connection Pool Parameters

The connection pool configuration is determined by the following `OracleOCIConnectionPool` class attributes:

- `CONNPOOL_MIN_LIMIT` : Specifies the minimum number of physical connections that can be maintained by the pool.
- `CONNPOOL_MAX_LIMIT` : Specifies the maximum number of physical connections that can be maintained by the pool.
- `CONNPOOL_INCREMENT` : Specifies the incremental number of physical connections to be opened when all the existing ones are busy and a call needs one more connection; the increment is done only when the total number of open physical connections is less than the maximum number that can be opened in that pool.
- `CONNPOOL_TIMEOUT` : Specifies how much time must pass before an idle physical connection is disconnected; this does not affect a logical connection.
- `CONNPOOL_NOWAIT` : When enabled, this attributes specifies that an error is returned if a call needs a physical connection while the maximum number of connections in the pool are busy; if disabled, a call waits until a connection is available. Once this attribute is set to "`true`", it cannot be reset to "`false`".

You can configure all of these attributes dynamically. Therefore, an application has the flexibility of reading the current load (number of open connections and number of

busy connections) and adjusting these attributes appropriately, using the `setPoolConfig()` method.

> **Note:** The default values for the `CONNPOOL_MIN_LIMIT`, `CONNPOOL_MAX_LIMIT`, and `CONNPOOL_INCREMENT` parameters are `1`, `1`, and `0`, respectively.

The `setPoolConfig()` method is used to configure OCI connection pool properties. The following is a typical example of how the `OracleOCIConnectionPool` class attributes can be set:

```
...
java.util.Properties p  = new java.util.Properties( );
p.put (OracleOCIConnectionPool.CONNPOOL_MIN_LIMIT, "1");
p.put (OracleOCIConnectionPool.CONNPOOL_MAX_LIMIT, "5");
p.put (OracleOCIConnectionPool.CONNPOOL_INCREMENT, "2");
p.put (OracleOCIConnectionPool.CONNPOOL_TIMEOUT, "10");
p.put (OracleOCIConnectionPool.CONNPOOL_NOWAIT, "true");
cpool.setPoolConfig(p);
...
```

Observe the following rules when setting the above attributes:

- `CONNPOOL_MIN_LIMIT`, `CONNPOOL_MAX_LIMIT`, and `CONNPOOL_INCREMENT` are mandatory.
- `CONNPOOL_MIN_LIMIT` must be a value greater than zero.
- `CONNPOOL_MAX_LIMIT` must be a value greater than or equal to `CONNPOOL_MIN_LIMIT` plus `CONNPOOL_INCREMENT`.
- `CONNPOOL_INCREMENT` must be a value greater than or equal to zero
- `CONNPOOL_TIMEOUT` must be a value greater than zero.
- `CONNPOOL_NOWAIT` must be "`true`" or "`false`" (case insensitive).

Checking the OCI Connection Pool Status

To check the status of the connection pool, use the following methods from the `OracleOCIConnectionPool` class:

- `int getMinLimit()` : Retrieves the minimum number of physical connections that can be maintained by the pool.
- `int getMaxLimit()` : Retrieves the maximum number of physical connections that can be maintained by the pool.
- `int getConnectionIncrement()` : Retrieves the incremental number of physical connections to be opened when all the existing ones are busy and a call needs a connection.
- `int getTimeout()` : Retrieves the specified time (in seconds) that a physical connection in a pool can remain idle before it is disconnected; the age of a connection is based on the Least Recently Used (LRU) scheme.
- `String getNoWait()` : Retrieves whether the `NOWAIT` property is enabled. It returns a string of "`true`" or "`false`".
- `int getPoolSize()` : Retrieves the number of physical connections that are open. This should be used only as an estimate and for statistical analysis.

- `int getActiveSize()` : Retrieves the number of physical connections that are open and busy. This should be used only as an estimate and for statistical analysis.
- `boolean isPoolCreated()` : Retrieves whether the pool has been created. The pool is actually created when `OracleOCIConnection (user, password, url, poolConfig)` is called or when `setUser`, `setPassword`, and `setURL` has been done after calling `OracleOCIConnection()`.

Connecting to an OCI Connection Pool

The `OracleOCIConnectionPool` class, through a `getConnection()` method call, creates an instance of the `OracleOCIConnection` class. This instance represents a connection. See "Datasources" on page 3-1 for database connection descriptions that apply to all JDBC drivers.

Since the `OracleOCIConnection` class extends `OracleConnection` class, it has the functionality of this class too. Close the `OracleOCIConnection` objects once the user session is over, otherwise, they are closed when the pool instance is closed.

There are two ways of calling `getConnection()`:

- `OracleConnection getConnection(String user, String password)` : Get a logical connection identified with the specified user and password, which can be different from that used for pool creation.
- `OracleConnection getConnection()` : If you do not supply the user name and password, then the default user name and password used for the creation of the connection pool are used while creating the connection objects.

As an enhancement to `OracleConnection`, the following new method is added into `OracleOCIConnection` as a way to change password for the user:

```
void passwordChange (String user, String oldPassword, String newPassword)
```

The following code shows how an application uses connection pool with re-configuration:

```
import oracle.jdbc.oci.*;
import oracle.jdbc.pool.*;

public class cpoolTest
{
  public static void main (String args [])
    throws SQLException
  {
    /* pass the URL and "inst1" as the database link name from tnsnames.ora */
    OracleOCIConnectionPool cpool = new OracleOCIConnectionPool
      ("scott", "tiger", "jdbc:oracle:oci@inst1", null);

    /* create virtual connection objects from the connection pool "cpool." The
       poolConfig can be null when using default values of min = 1, max = 1, and
       increment = 0, otherwise needs to set the properties mentioned earlier */
    OracleOCIConnection conn1 = (OracleOCIConnection) cpool.getConnection
      ("user1", password1");

    /* create few Statement objects and work on this connection, conn1 */
    Statement stmt = conn1.createStatement();
    ...
    OracleOCIConnection conn90 = (OracleOCIConnection) cpool.getConnection
      ("user90", "password90")   /* work on statement object from virtual
```

```
                                    connection "conn90" */
    ...
    /* if the throughput is less, increase the pool size */
    String newmin = String.valueOf (cpool.getMinLimit);
    String newmax = String.valueOf (2*cpool.getMaxLimit());
    String newincr = String.valueOf (1 + cpool.getConnectionIncrement());
    Properties newproperties = newProperties();
    newproperties.put (OracleOCIConnectionPool.CONNPOOL_MIN_LIMIT, newmin);
    newproperties.put (OracleOCIConnectionPool.CONNPOOL_MAX_LIMIT, newmax);
    newproperties.put (OracleOCIConnectionPool.CONNPOOL_INCREMENT, newincr);
    cpool.setPoolConfig (newproperties);
    }  /* end of main */
}  /* end of cpoolTest */
```

Statement Handling and Caching

Statement caching is supported with `OracleOCIConnectionPool`. The caching improves performance by not having to open, parse and close cursors. When `OracleOCIConnection.prepareStatement` ("SQL query") is done, the statement cache is searched for a statement that matches the SQL query. If a match is found, we can reuse the `Statement` object instead of incurring the cost of creating another `Statement` object. The cache size can be dynamically increased or decreased. The default cache size is zero.

> **Note:** The `OracleStatement` object created from `OracleOCIConnection` has the same behavior as one that is created from `OracleConnection`.

The following code shows the signatures of the `getConnection()` method:

```
public synchronized OracleConnection getConnection( )
                    throws SQLException

/*
 * For getting a connection to the database.
 *
 * @param us  Connection user-id
 * @param p   Connection password
 * @return     connection object
 */
public synchronized OracleConnection getConnection(String us, String p)
throws SQLException
```

JNDI and the OCI Connection Pool

The Java Naming and Directory Interface (JNDI) feature makes persistent the properties of Java object so these properties can be used to construct a new instance of the object (such as cloning the object). The benefit is that the old object can be freed, and at a later time a new object with exactly the same properties can be created. The `InitialContext.bind()` method makes persistent the properties, either on file or in a database, while the `InitialContext.lookup()` method retrieves the properties from the persistent store and creates a new object with these properties.

`OracleOCIConnectionPool` objects can be bound and looked up using the JNDI feature. No new interface calls in `OracleOCIConnectionPool` are necessary.

OCI Driver Transparent Application Failover

Transparent Application Failover (TAF) is a feature of the OCI driver. It enables you to automatically reconnect to a database if the database instance to which the connection is made goes down. In this case, the active transactions roll back. (A transaction rollback restores the last committed transaction.) The new database connection, though created by a different node, is identical to the original. This is true regardless of how the connection was lost.

TAF is always active and does not have to be set.

> **Note:** TAF does not work with the OCI Connection Pool.

For additional details regarding OCI and TAF, see the *Programmer's Guide to the Oracle Call Interface*.

Failover Type Events

The following are possible failover events in the `OracleOCIFailover` interface:

- `FO_SESSION` : Is equivalent to `FAILOVER_MODE=SESSION` in the `tnsnames.ora` file `CONNECT_DATA` flags. This means that only the user session is re-authenticated on the server-side while open cursors in the OCI application need to be re-executed.
- `FO_SELECT` : Is equivalent to `FAILOVER_MODE=SELECT` in `tnsnames.ora` file `CONNECT_DATA` flags. This means that not only the user session is re-authenticated on the server-side, but open cursors in the OCI can continue fetching. This implies that the client-side logic maintains fetch-state of each open cursor.
- `FO_NONE` : Is equivalent to `FAILOVER_MODE=NONE` in the `tnsnames.ora` file `CONNECT_DATA` flags. This is the default, in which no failover functionality is used. This can also be explicitly specified to prevent failover from happening. Additionally, `FO_TYPE_UNKNOWN` implies that a bad failover type was returned from the OCI driver.
- `FO_BEGIN` : Indicates that failover has detected a lost connection and failover is starting.
- `FO_END` : Indicates successful completion of failover.
- `FO_ABORT` : Indicates that failover was unsuccessful and there is no option of retrying.
- `FO_REAUTH` : indicates that a user handle has been re-authenticated.
- `FO_ERROR` : indicates that failover was temporarily un-successful, but it gives the application the opportunity to handle the error and retry failover. The usual method of error handling is to issue the `sleep()` method and retry by returning the value `FO_RETRY`.
- `FO_RETRY` : See above.
- `FO_EVENT_UNKNOWN` : A bad failover event.

TAF Callbacks

TAF callbacks are used in the event of the failure of one database connection, and failover to another database connection. *TAF callbacks* are callbacks that are registered

in case of failover. The callback is called during the failover to notify the JDBC application of events generated. The application also has some control of failover.

Note: The callback setting is optional.

Java TAF Callback Interface

The `OracleOCIFailover` interface includes the `callbackFn()` method, supporting the following types and events:

```
public interface OracleOCIFailover{

// Possible Failover Types
public static final int FO_SESSION = 1;
public static final int FO_SELECT  = 2;
public static final int FO_NONE  = 3;
public static final int;

// Possible Failover events registered with callback
public static final int FO_BEGIN   = 1;
public static final int FO_END     = 2;
public static final int FO_ABORT   = 3;
public static final int FO_REAUTH  = 4;
public static final int FO_ERROR  = 5;
public static final int FO_RETRY  = 6;
public static final int FO_EVENT_UNKNOWN = 7;

public int callbackFn (Connection conn,
                       Object ctxt, // ANy thing the user wants to save
                       int type, // One of the above possible Failover Types
                       int event ); // One of the above possible Failover Events
```

Handling the FO_ERROR Event

In case of an error while failing-over to a new connection, the JDBC application is able to retry failover. Typically, the application sleeps for a while and then it retries, either indefinitely or for a limited amount of time, by having the callback return `FO_RETRY`.

Handling the FO_ABORT Event

Callback registered should return the `FO_ABORT` event if the `FO_ERROR` event is passed to it.

OCI HeteroRM XA

HeteroRM XA is enabled through the use of the `tnsEntry` and `nativeXA` properties of the `OracleXADataSource` class. Table 3–2, " Oracle Extended Datasource Properties" on page 3-4 explains these properties in detail.

For a complete discussion of XA, see Chapter 9, "Distributed Transactions".

Configuration and Installation

The Solaris shared libraries, `libheteroxa10.so` and `libheteroxa10_g.so`, enable the HeteroRM XA feature. The Windows versions of these libraries are `heteroxa10.dll` and `heteroxa10_g.dll`. In order for the HeteroRM XA feature to work properly, these libraries need to be installed and available in either the Solaris search path or the Windows DLL path, depending on your system.

Note: Libraries with the `_g` suffix are debug libraries.

Exception Handling

When using the HeteroRM XA feature in distributed transactions, it is recommended that the application simply check for `XAException` or `SQLException`, rather than `OracleXAException` or `OracleSQLException`.

See "HeteroRM XA Messages" on page A-9 for a listing of HeteroRM XA messages.

Note: The mapping from SQL error codes to standard XA error codes does not apply to the HeteroRM XA feature.

HeteroRM XA Code Example

The following portion of code shows how to enable the HeteroRM XA feature.

```
// Create a XADataSource instance
OracleXADataSource oxds = new OracleXADataSource();
oxds.setURL(url);

// Set the nativeXA property to use HeteroRM XA feature
oxds.setNativeXA(true);

// Set the tnsEntry property to an older DB as required
oxds.setTNSEntryName("ora805");
```

Accessing PL/SQL Index-by Tables

The Oracle JDBC OCI driver enables JDBC applications to make PL/SQL calls with index-by table parameters.

Important: Index-by tables of PL/SQL records are not supported.

Overview

The Oracle JDBC OCI driver supports PL/SQL index-by tables of scalar datatypes. Table 19–1 displays the supported scalar types and the corresponding JDBC typecodes.

Table 19–1 PL/SQL Types and Corresponding JDBC Types

PL/SQL Types	JDBC Types
BINARY_INTEGER	NUMERIC
NATURAL	NUMERIC
NATURALN	NUMERIC
PLS_INTEGER	NUMERIC
POSITIVE	NUMERIC
POSITIVEN	NUMERIC
SIGNTYPE	NUMERIC
STRING	VARCHAR

Note: Oracle JDBC does not support RAW, DATE, and PL/SQL RECORD as element types.

Typical Oracle JDBC input binding, output registration, and data-access methods do not support PL/SQL index-by tables. This chapter introduces additional methods to support these types.

The OraclePreparedStatement and OracleCallableStatement classes define the additional methods. These methods include the following:

- setPlsqlIndexTable()
- registerIndexTableOutParameter()
- getOraclePlsqlIndexTable()
- getPlsqlIndexTable()

These methods handle PL/SQL index-by tables as IN, OUT (including function return values), or IN OUT parameters. For general information about PL/SQL syntax, see the *PL/SQL User's Guide and Reference*.

The following sections describe the methods used to bind and register PL/SQL index-by tables.

Binding IN Parameters

To bind a PL/SQL index-by table parameter in the IN parameter mode, use the setPlsqlIndexTable() method defined in the OraclePreparedStatement and OracleCallableStatement classes.

```
synchronized public void setPlsqlIndexTable
   (int paramIndex, Object arrayData, int maxLen, int curLen, int elemSqlType,
   int elemMaxLen) throws SQLException
```

Table 19–2 describes the arguments of the `setPlsqlIndexTable()` method.

Table 19–2 Arguments of the setPlsqlIndexTable () Method

Argument	Description
`int paramIndex`	This argument indicates the parameter position within the statement.
`Object arrayData`	This argument is an array of values to be bound to the PL/SQL index-by table parameter. The value is of type `java.lang.Object`, and the value can be a Java primitive type array such as `int[]` or a Java object array such as `BigDecimal[]`.
`int maxLen`	This argument specifies the maximum table length of the index-by table bind value which defines the maximum possible `curLen` for batch updates. For standalone binds, `maxLen` should use the same value as `curLen`. This argument is required.
`int curLen`	This argument specifies the actual size of the index-by table bind value in `arrayData`. If the `curLen` value is smaller than the size of `arrayData`, only the `curLen` number of table elements is passed to the database. If the `curLen` value is larger than the size of `arrayData`, the entire `arrayData` is sent to the database.
`int elemSqlType`	This argument specifies the index-by table element type based on the values defined in the `OracleTypes` class.
`int elemMaxLen`	This argument specifies the index-table element maximum length in case the element type is `CHAR`, `VARCHAR`, or `RAW`. This value is ignored for other types.

The following code example uses the `setPlsqlIndexTable()` method to bind an index-by table as an `IN` parameter:

```
// Prepare the statement
OracleCallableStatement procin = (OracleCallableStatement)
   conn.prepareCall ("begin procin (?); end;");

// index-by table bind value
int[] values = { 1, 2, 3 };

// maximum length of the index-by table bind value. This
// value defines the maximum possible "currentLen" for batch
// updates. For standalone binds, "maxLen" should be the
// same as "currentLen".
int maxLen = values.length;

// actual size of the index-by table bind value
int currentLen = values.length;

// index-by table element type
int elemSqlType = OracleTypes.NUMBER;

// index-by table element length in case the element type
// is CHAR, VARCHAR or RAW. This value is ignored for other
// types.
int elemMaxLen = 0;

// set the value
```

```
procin.setPlsqlIndexTable (1, values,
                           maxLen, currentLen,
                           elemSqlType, elemMaxLen);

// execute the call
procin.execute ();
```

Receiving OUT Parameters

This section describes how to register a PL/SQL index-by table as an `OUT` parameter. In addition, it describes how to access the `OUT` bind values in various mapping styles.

> **Note:** The methods this section describes apply to function return values and the `IN OUT` parameter mode as well.

Registering the OUT Parameters

To register a PL/SQL index-by table as an `OUT` parameter, use the `registerIndexTableOutParameter()` method defined in the `OracleCallableStatement` class.

```
synchronized public void registerIndexTableOutParameter
   (int paramIndex, int maxLen, int elemSqlType, int elemMaxLen)
   throws SQLException
```

Table 19–3 describes the arguments of the `registerIndexTableOutParameter()` method.

Table 19–3 Arguments of the registerIndexTableOutParameter () Method

Argument	Description
`int paramIndex`	This argument indicates the parameter position within the statement.
`int maxLen`	This argument specifies the maximum table length of the index-by table bind value to be returned.
`int elemSqlType`	This argument specifies the index-by table element type based on the values defined in the `OracleTypes` class.
`int elemMaxLen`	This argument specifies the index-by table element maximum length in case the element type is `CHAR`, `VARCHAR`, or `FIXED_CHAR`. This value is ignored for other types.

The following code example uses the `registerIndexTableOutParameter()` method to register an index-by table as an `OUT` parameter:

```
// maximum length of the index-by table value. This
// value defines the maximum table size to be returned.
int maxLen = 10;

// index-by table element type
int elemSqlType = OracleTypes.NUMBER;

// index-by table element length in case the element type
// is CHAR, VARCHAR or FIXED_CHAR. This value is ignored for other
// types
int elemMaxLen = 0;

// register the return value
```

```
funcnone.registerIndexTableOutParameter
   (1, maxLen, elemSqlType, elemMaxLen);
```

Accessing the OUT Parameter Values

To access the `OUT` bind value, the `OracleCallableStatement` class defines multiple methods that return the index-by table values in different mapping styles. There are three mapping choices available in JDBC drivers:

Mappings	Methods to Use
JDBC default mappings	`getPlsqlIndexTable(int)`
Oracle mappings	`getOraclePlsqlIndexTable(int)`
Java primitive type mappings	`getPlsqlIndexTable(int, Class)`

JDBC Default Mappings The `getPlsqlIndexTable()` method with the `(int)` signature returns index-by table elements using JDBC default mappings.

```
public Object getPlsqlIndexTable (int paramIndex)
   throws SQLException
```

Table 19–4 describes the argument of the `getPlsqlIndexTable()` method.

Table 19–4 Argument of the getPlsqlIndexTable () Method

Argument	Description
`int paramIndex`	This argument indicates the parameter position within the statement.

The return value is a Java array. The elements of this array are of the default Java type corresponding to the SQL type of the elements. For example, for an index-by table with elements of `NUMERIC` typecode, the element values are mapped to `BigDecimal` by the Oracle JDBC driver, and the `getPlsqlIndexTable()` method returns a `BigDecimal[]` array. For a JDBC application, you must cast the return value to a `BigDecimal[]` array to access the table element values. (See "Datatype Mappings" on page 4-12 for a list of default mappings.)

The following code example uses the `getPlsqlIndexTable()` method to return index-by table elements with JDBC default mapping:

```
// access the value using JDBC default mapping
BigDecimal[] values =
   (BigDecimal[]) procout.getPlsqlIndexTable (1);

// print the elements
for (int i=0; i<values.length; i++)
   System.out.println (values[i].intValue());
```

Oracle Mappings The `getOraclePlsqlIndexTable()` method returns index-by table elements using Oracle mapping.

```
public Datum[] getOraclePlsqlIndexTable (int paramIndex)
      throws SQLException
```

Table 19–5 describes the argument of the `getOraclePlsqlIndexTable()` method.

Table 19–5 Argument of the getOraclePlsqlIndexTable () Method

Argument	Description
`int paramIndex`	This argument indicates the parameter position within the statement.

The return value is an `oracle.sql.Datum` array and the elements in the `Datum` array will be the default `Datum` type corresponding to the SQL type of the element. For example, the element values of an index-by table of numeric elements are mapped to the `oracle.sql.NUMBER` type in Oracle mapping, and the `getOraclePlsqlIndexTable()` method returns an `oracle.sql.Datum` array that contains `oracle.sql.NUMBER` elements.

The following code example uses the `getOraclePlsqlIndexTable()` method to access the elements of a PL/SQL index-by table `OUT` parameter, using Oracle mapping. (The code for registration is omitted.)

```
// Prepare the statement
OracleCallableStatement procout = (OracleCallableStatement)
                                  conn.prepareCall ("begin procout (?); end;");

...

// execute the call
procout.execute ();

// access the value using Oracle JDBC mapping
Datum[] outvalues = procout.getOraclePlsqlIndexTable (1);

// print the elements
for (int i=0; i<outvalues.length; i++)
   System.out.println (outvalues[i].intValue());
```

Java Primitive Type Mappings The `getPlsqlIndexTable()` method with the `(int, Class)` signature returns index-by table elements in Java primitive types. The return value is a Java array.

```
synchronized public Object getPlsqlIndexTable
   (int paramIndex, Class primitiveType) throws SQLException
```

Table 19–4 describes the arguments of the `getPlsqlIndexTable()` method.

Table 19–6 Arguments of the getPlsqlIndexTable () Method

Argument	Description
`int paramIndex`	This argument indicates the parameter position within the statement.

`Class primitiveType`	This argument specifies a Java primitive type to which the index-by table elements are to be converted. For example, if you specify `java.lang.Integer.TYPE`, the return value is an `int` array.
	The following are the possible values of this parameter:
	`java.lang.Integer.TYPE`
	`java.lang.Long.TYPE`
	`java.lang.Float.TYPE`
	`java.lang.Double.TYPE`
	`java.lang.Short.TYPE`

The following code example uses the `getPlsqlIndexTable()` method to access the elements of a PL/SQL index-by table of numbers. In the example, the second parameter specifies `java.lang.Integer.TYPE`, so the return value of the `getPlsqlIndexTable()` method is an `int` array.

```
OracleCallableStatement funcnone = (OracleCallableStatement)
   conn.prepareCall ("begin ? := funcnone; end;");

// maximum length of the index-by table value. This
// value defines the maximum table size to be returned.
int maxLen = 10;

// index-by table element type
int elemSqlType = OracleTypes.NUMBER;

// index-by table element length in case the element type
// is CHAR, VARCHAR or RAW. This value is ignored for other
// types
int elemMaxLen = 0;

// register the return value
funcnone.registerIndexTableOutParameter (1, maxLen,
                                         elemSqlType, elemMaxLen);
// execute the call
funcnone.execute ();

// access the value as a Java primitive array.
int[] values = (int[])
   funcnone.getPlsqlIndexTable (1, java.lang.Integer.TYPE);

// print the elements
for (int i=0; i<values.length; i++)
   System.out.println (values[i]);
```

20

OCI Instant Client

This chapter contains these topics:

Overview

The Instant Client feature makes it extremely easy to deploy OCI, OCCI, ODBC, and JDBC-OCI based customer applications by eliminating the need for an `ORACLE_HOME`. The storage space requirement of a JDBC OCI application running in Instant Client mode is significantly reduced compared to the same application running in a full client side installation. The Instant Client shared libraries only occupy about one-fourth the disk space of a full client installation.

Table 20–1 shows the Oracle client-side files required to deploy a JDBC OCI application:

Table 20–1 OCI Instant Client Shared Libraries

UNIX	Windows	Description
`libclnstsh.so.10.1`	`oci.dll`	Client Code Library
`libociei.so`	`oraociei10.dll`	OCI Instant Client Data Shared Library
`libnnz10.so`	`orannzsbb10.dll`	Security Library
`libocijdbc10.so`	`oraocijdbc10.dll`	OCI Instant Client JDBC Library
n/a	n/a	All JDBC JAR files (see "Check the Environment Variables" on page 2-3)

Release 10.1 library names are used in the table. The number part of library names will change in future releases to agree with the release.

Note: To provide native XA functionality (also known as HeteroRM XA functionality), you must copy the JDBC XA class library. On Unix platforms, this library, called `libheteroxa10.so`, is available in *`ORACLE_HOME`*`/jdbc/lib`. On Windows, this library, called `heteroxa10.dll`, is located in *`ORACLE_HOME`*`\bin`.

Benefits of Instant Client

The benefits of Instant Client are:

- Installation involves copying a small number of files.
- The Oracle client-side number of required files and the total disk storage are significantly reduced.
- There is no loss of functionality or performance for applications deployed in Instant Client mode.
- It is simple for independent software vendors to package applications.

JDBC OCI Instant Client Installation Process

The Instant Client libraries can be installed by choosing the Instant Client option from the Oracle Universal Installer. The Instant Client libraries can also be downloaded from the Oracle Technology Network (`otn.oracle.com`) Web site. The installation process is as simple as:

1. Downloading and installing the Instant Client shared libraries and Oracle JDBC class libraries to a directory such as `instantclient`.
2. Setting the OS shared library path environment variable to the directory from step 1. For example, on UNIX, set the LD_LIBRARY_PATH to `instantclient`. On Windows, set PATH to locate the `instantclient` directory.
3. Adding the full pathnames of the JDBC class libraries to the CLASSPATH environment variable; see "Check the Environment Variables" on page 2-3.

After completing the above steps you are ready to run the JDBC OCI application.

The JDBC OCI application operates in Instant Client mode when the OCI and JDBC shared libraries are accessible through the OS Library Path variable. In this mode, there is no dependency on `ORACLE_HOME` and none of the other code and data files provided in `ORACLE_HOME` are needed by JDBC OCI (except for the `tnsnames.ora` file described later).

If you have done a complete client installation (by choosing the Admin option), the Instant Client shared libraries are also installed. The location of the Instant Client shared libraries and JDBC class libraries in a full client installation is:

On UNIX:

- `libociei.so` library is in `$ORACLE_HOME/instantclient`
- `libclnstsh.so.10.1`, `libocijdbc10.so`, and `libnnz10.so` are in `$ORACLE_HOME/lib`
- The JDBC class libraries are in `$ORACLE_HOME/jdbc/lib`

On Windows:

- `oraociei10.dll` library is in `ORACLE_HOME\instantclient`

- oci.dll, oraocijdbc10.dll, and orannzsbb10.dll are in ORACLE_HOME\bin
- The JDBC class libraries are in ORACLE_HOME\jdbc\lib

By copying the above files to a different directory, setting the OS shared library path to locate this directory, and adding the pathnames of the JDBC class libraries to the CLASSPATH, you can enable running the JDBC OCI application in Instant Client mode.

Notes:
- To provide native XA functionality (also known as HeteroRM XA functionality), you must copy the JDBC XA class library. On Unix platforms, this library, called libheteroxa10.so, is available in *ORACLE_HOME*/jdbc/lib. On Windows, this library, called heteroxa10.dll, is located in *ORACLE_HOME*\bin.
- All the libraries must be copied from the same ORACLE_HOME and must be placed in the same directory.
- On hybrid platforms, such as Sparc64, if the JDBC OCI driver needs to be operated in the Instant Client mode, you must copy the libociei.so library from the ORACLE_HOME/instantclient32 directory. You must copy all other Sparc64 libraries needed for the JDBC OCI Instant Client from the ORACLE_HOME/lib32 directory.

When to Use Instant Client

Instant Client is a deployment feature and should be used for running production applications. For development, a full installation is necessary to access demonstration programs and so on. In general, all JDBC OCI functionality is available to an application being run in the Instant Client mode, except that the Instant Client mode is for client-side operation only. Therefore, server-side external procedures cannot operate in the Instant Client mode.

Patching Instant Client Shared Libraries

Because Instant Client is a deployment feature, the emphasis has been on reducing the number and size of files (client footprint) required to run a JDBC OCI application. Hence all files needed to patch Instant Client shared libraries are not available in an Instant Client deployment. An ORACLE_HOME based full client installation is needed to patch the Instant Client shared libraries. The opatch utility will take care of patching the Instant Client shared libraries.

After patching the Instant Client shared libraries Oracle recommends generating the patch inventory information by executing the following command from the ORACLE_HOME/OPatch directory:

```
opatch lsinventory > opatchinv.out
```

The opatchinv.out file should be copied along with the patched Instant Client libraries to the deployment directory. The information in opatchinv.out will indicate all the patches that have been applied.

The opatch inventory information for Instant Client libraries is not needed on the Windows platform, so this step can be skipped on Windows.

Regeneration of Data Shared Library

The OCI Instant Client Data Shared Library (`libociei.so`) can be regenerated by performing the following steps in an Administrator Install of `ORACLE_HOME`:

```
cd $ORACLE_HOME/rdbms/lib
make -f ins_rdbms.mk ilibociei
```

A new version of `libociei.so` based on the current files in the `ORACLE_HOME` is then placed in the `ORACLE_HOME/instantclient` directory.

Regeneration of data shared library is not available on Windows platforms.

Database Connection Names for OCI Instant Client

All Oracle net naming methods that do not require use of `ORACLE_HOME` or `TNS_ADMIN` (to locate configuration files such as `tnsnames.ora` or `sqlnet.ora`) work in the Instant Client mode. In particular, the connect string can be specified in the following formats:

- A Thin-style connect string of the form:

  host:*port*:*service_name*

  such as:

  ```
  url="jdbc:oracle:oci:@//example.com:5521:bjava21"
  ```

- A SQL Connect URL string of the form:

  ```
  //host:[port][/service name]
  ```

  such as:

  ```
  url="jdbc:oracle:oci:@//example.com:5521/bjava21
  ```

- As an Oracle Net keyword-value pair. For example:

  ```
  url="jdbc:oracle:oci:@(DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)
    (HOST=dlsun242) (PORT=5521))
    (CONNECT_DATA=(SERVICE_NAME=bjava21)))"
  ```

Naming methods that require `TNS_ADMIN` to locate configuration files continue to work if the `TNS_ADMIN` environment variable is set.

If the `TNS_ADMIN` environment variable is not set, and `TNSNAMES` entries such as `inst1`, and so on, are used, then the `ORACLE_HOME` variable must be set, and the configuration files are expected to be in the `$ORACLE_HOME/network/admin` directory.

Please note that the `ORACLE_HOME` variable in this case is only used for locating Oracle Net configuration files, and no other component of Client Code Library (OCI, NLS, and so on) uses the value of `ORACLE_HOME`.

The bequeath adapter or the empty connect strings are not supported. However, an alternate way to use the empty connect string is to set the `TWO_TASK` environment variable on UNIX, or the `LOCAL` variable on Windows, to either a `tnsnames.ora` entry or an Oracle Net keyword-value pair. If `TWO_TASK` or `LOCAL` is set to a `tnsnames.ora` entry, then the `tnsnames.ora` file must be able to be loaded by `TNS_ADMIN` or `ORACLE_HOME` setting.

Environment Variables for OCI Instant Client

The ORACLE_HOME environment variable no longer determines the location of NLS, CORE, and error message files. An OCI-only application should not require ORACLE_HOME to be set. However, if it is set, it does not have an impact on the OCI driver's operation. OCI will always obtain its data from the Data Shared Library. If the Data Shared Library is not available, only then is ORACLE_HOME used and a full client installation is assumed. Even though ORACLE_HOME is not required to be set, if it is set, then it must be set to a valid operating system path name that identifies a directory.

Environment variables ORA_NLS33 and ORA_NLSPROFILES33 are ignored in the Instant Client mode.

In the Instant Client mode, if the ORA_TZFILE variable is not set, then the smaller, default, timezone.dat file from the Data Shared Library is used. If the larger timezlrg.dat file is to be used from the Data Shared Library, then set the ORA_TZFILE environment variable to the name of the file without any absolute or relative path names. That is, on UNIX:

```
setenv ORA_TZFILE timezlrg.dat
```

On Windows:

```
set ORA_TZFILE timezlrg.dat
```

If the driver is not operating in the Instant Client mode (because the Data Shared Library is not available), then ORA_TZFILE variable, if set, names a complete path name as it does in previous Oracle releases.

If TNSNAMES entries are used, then, as mentioned earlier, TNS_ADMIN directory must contain the TNSNAMES configuration files, and if TNS_ADMIN is not set, then the ORACLE_HOME/network/admin directory must contain Oracle Net Services configuration files.

21

End-To-End Metrics Support

Oracle JDBC now supports end-to-end metrics when used with an Oracle 10*g* database. This chapter discusses end-to-end metric support. It contains the following sections:

Introduction

JDBC supports four end-to-end metrics, all of which are set on a per-connection basis:

- Action—`String`
- ClientId—`String`
- ExecutionContextId—`String` and `short SequenceNumber`)
- Module—`String`

All of these metrics are set on a per-connection basis. All operations on a given connection share the same values. Applications normally set these metrics using DMS; although it is also possible to set metrics using JDBC, metrics set using DMS (Dynamic Monitoring Service) override metrics set using JDBC. To use DMS directly, you must be using a DMS-enabled JAR, which is only available as part of Oracle Application Server.

When a connection is created, the JDBC drivers check DMS for end-to-end metrics. It only makes this check once during the lifetime of the connection.

- **If DMS metrics are not set**, then JDBC never checks DMS for metrics again. Thereafter, each time JDBC communicates with the database, it sends any updated metric values to the database. (These metric values would have been updated through the JDBC interface, not through DMS.)

  If DMS metrics are set, then JDBC ignores the end-to-end metric API described in this chapter. Thereafter, each time JDBC communicates with the database, it checks with DMS for updated metric values, and, if it finds them, propagates them to the database.

- **If no metrics are set**, then no metrics are sent to the database.

JDBC API For End-To-End Metrics

If DMS is not in use, either because a non-DMS JAR is in use or because no metric values were set in DMS, the JDBC API is used.

The JDBC API defines the following constants and methods on `OracleConnection`:

- `String[] getEndToEndMetrics()throws SQLException;`
- `void setEndToEndMetrics(String[] metrics, short sequenceNumber) throws SQLException;`
- `END_TO_END_ACTION_INDEX`—the index of the `ACTION` metric within the `String` array of metrics.
- `END_TO_END_CLIENTID_INDEX`—the index of the `CLIENTID` metric within the `String` array of metrics.
- `END_TO_END_MODULE_INDEX`—the index of the `MODULE` metric within the `String` array of metrics.
- `END_TO_END_ECID_INDEX`—the index of the string component of the `ECID` metric within the `String` array of metrics. This component is not used by Oracle 10*g*.
- `END_TO_END_STATE_INDEX_MAX` —this is the size of the `String` array containing the metric values.
- `short getEndToEndECIDSequenceNumber();`—returns the current value of the `SequenceNumber` component of the `ECID`. This component is not used by Oracle 10*g*.

To unset the metrics, pass an array of appropriate size with all null values and the value `Short.MIN_VALUE` as the sequence number.

Example 21–1 Using the JDBC API for End-to-end Metrics

```
ods.setUrl(
"jdbc:oracle:oci:@(DESCRIPTION=
  (ADDRESS=(PROTOCOL=TCP)(HOST=cluster_alias)
    (PORT=1521))
    (CONNECT_DATA=(SERVICE_NAME=service_name)))");
ods.setUser("scott");
Connection conn = ods.getConnection();

String metrics = new String[OracleConnection.END_TO_END_STATE_INDEX_MAX];
metrics[END_TO_END_ACTION_INDEX] = "Spike";
metrics[END_TO_END_MODULE_INDEX] = "Buffy";
// Set these metrics
conn.setEndToEndMetrics(metrics, (short) 0);
// Do some work
// Update a metric
metrics[END_TO_END_MODULE_INDEX] = "Faith";

conn.setEndToEndMetrics(metrics, (short) 0);
// Retrieve metrics
new String[] newMetrics = conn.getEndToEndMetrics();
```

22

Performance Extensions

This chapter describes the Oracle performance extensions to the JDBC standard. In the course of discussing update batching, it also includes a discussion of the standard update-batching model provided with JDBC 2.0.

This chapter covers the following topics:

- Update Batching
- Additional Oracle Performance Extensions

> **Note:** For a general overview of Oracle extensions and detailed discussion of Oracle packages and type extensions, see Chapter 10, "Oracle Extensions".

Update Batching

You can reduce the number of round trips to the database, thereby improving application performance, by grouping multiple `UPDATE`, `DELETE`, or `INSERT` statements into a single "batch" and having the whole batch sent to the database and processed in one trip. This is referred to in this manual as *update batching* and in the Sun Microsystems JDBC 2.0 specification as *batch updates*.

This is especially useful with prepared statements, when you are repeating the same statement with different bind variables.

Oracle JDBC supports two distinct models for update batching:

- the standard model, implementing the Sun Microsystems JDBC 2.0 Specification, which is referred to as *standard update batching*
- the Oracle-specific model, independent of the Sun Microsystems JDBC 2.0 Specification, which is referred to as *Oracle update batching*

> **Note:** It is important to be aware that you cannot mix theses models. In any single application, you can use the syntax of one model or the other, but not both. The Oracle JDBC driver will throw exceptions when you mix these syntaxes.

Overview of Update Batching Models

This section compares and contrasts the general models and types of statements supported for standard update batching and Oracle update batching.

Oracle Model versus Standard Model

Oracle update batching uses a *batch value* that typically results in implicit processing of a batch. The batch value is the number of operations you want to batch (accumulate) for each trip to the database. As soon as that many operations have been added to the batch, the batch is executed. Note the following:

- You can set a default batch for the connection object, which applies to any prepared statement executed in that connection.
- For any individual prepared statement object, you can set a statement batch value that overrides the connection batch value.
- You can choose to explicitly execute a batch at any time, overriding both the connection batch value and the statement batch value.

Standard update batching is a manual, explicit model. There is no batch value. You manually add operations to the batch and then explicitly choose when to execute the batch.

Oracle update batching is a more efficient model because the driver knows ahead of time how many operations will be batched. In this sense, the Oracle model is more static and predictable. With the standard model, the driver has no way of knowing in advance how many operations will be batched. In this sense, the standard model is more dynamic in nature.

If you want to use update batching, here is how to choose between the two models:

- Use Oracle update batching if portability is not critical. This will probably result in the greatest performance improvement.
- Use standard update batching if portability is a higher priority than performance.

Types of Statements Supported

As implemented by Oracle, update batching is intended for use with prepared statements, when you are repeating the same statement with different bind variables. Be aware of the following:

- Oracle update batching supports *only* Oracle prepared statement objects. In an Oracle callable statement, both the connection default batch value and the statement batch value are overridden with a value of 1. In an Oracle generic

statement, there is no statement batch value, and the connection default batch value is overridden with a value of 1.

Note that because Oracle update batching is vendor-specific, you must actually use (or cast to) `OraclePreparedStatement` objects, not general `PreparedStatement` objects.

- To adhere to the JDBC 2.0 standard, Oracle's implementation of standard update batching supports callable statements (without OUT parameters) and generic statements, as well as prepared statements. You can migrate standard update batching syntax into an Oracle JDBC application without difficulty.
- You can batch only `UPDATE`, `INSERT`, or `DELETE` operations. Executing a batch that includes an operation that attempts to return a result set will cause an exception.

Note: The Oracle implementation of standard update batching does not implement true batching for generic statements and callable statements. Although Oracle JDBC supports the use of standard batching syntax for `Statement` and `CallableStatement` objects, you will see performance improvement for only `PreparedStatement` objects.

Note that with standard update batching, you can use either standard `PreparedStatement`, `CallableStatement`, and `Statement` objects, or Oracle-specific `OraclePreparedStatement`, `OracleCallableStatement`, and `OracleStatement` objects.

Oracle Update Batching

The Oracle update batching feature associates a batch value (limit) with each prepared statement object. With Oracle update batching, instead of the JDBC driver executing a prepared statement each time its `executeUpdate()` method is called, the driver adds the statement to a batch of accumulated execution requests. The driver will pass all the operations to the database for execution once the batch value is reached. For example, if the batch value is 10, then each batch of 10 operations will be sent to the database and processed in one trip.

A method in the `OracleConnection` class allows you to set a default batch value for the Oracle connection as a whole, and this batch value is relevant to any Oracle prepared statement in the connection. For any particular Oracle prepared statement, a method in the `OraclePreparedStatement` class allows you to set a statement batch value that overrides the connection batch value. You can also override both batch values by choosing to manually execute the pending batch.

Notes:

- Do not mix standard update batching syntax with Oracle update batching syntax in the same application. The JDBC driver will throw an exception when you mix these syntaxes.
- Disable auto-commit mode if you use either update batching model. In case an error occurs while you are executing a batch, this allows you the option of committing or rolling back the operations that executed successfully prior to the error.

Oracle Update Batching Characteristics and Limitations

Note the following limitations and implementation details regarding Oracle update batching:

- By default, there is no statement batch value, and the connection (default) batch value is 1.
- Batch values between 5 and 30 tend to be the most effective. Setting a very high value might even have a negative effect. It is worth trying different values to verify the effectiveness for your particular application.
- Regardless of the batch value in effect, if any of the bind variables of an Oracle prepared statement is (or becomes) a stream type, then the Oracle JDBC driver sets the batch value to 1 and sends any queued requests to the database for execution.
- The Oracle JDBC driver automatically executes the `sendBatch()` method of an Oracle prepared statement in any of the following circumstances: 1) the connection receives a `COMMIT` request, either as a result of invoking the `commit()` method or as a result of auto-commit mode; 2) the statement receives a `close()` request; or 3) the connection receives a `close()` request.

> **Note:** A connection `COMMIT` request, statement close, or connection close has no effect on a pending batch if you use standard update batching—only if you use Oracle update batching.

Setting the Connection Batch Value

You can specify a default batch value for any Oracle prepared statement in your Oracle connection. To do this, use the `setDefaultExecuteBatch()` method of the `OracleConnection` object. For example, the following code sets the default batch value to 20 for all prepared statement objects associated with the `conn` connection object:

```
((OracleConnection)conn).setDefaultExecuteBatch(20);
```

Even though this sets the default batch value for all the prepared statements of the connection, you can override it by calling `setDefaultBatch()` on individual Oracle prepared statements.

The connection batch value will apply to statement objects created after this batch value was set.

Note that instead of calling `setDefaultExecuteBatch()`, you can set the `defaultBatchValue` Java property if you use a Java `Properties` object in establishing the connection. See "Supported Connection Properties" on page 4-3.

Setting the Statement Batch Value

Use the following steps to set the statement batch value for a particular Oracle prepared statement. This will override any connection batch value set using the `setDefaultExecuteBatch()` method of the `OracleConnection` instance for the connection in which the statement executes.

1. Write your prepared statement and specify input values for the first row:

```
PreparedStatement ps = conn.prepareStatement
                              ("INSERT INTO dept VALUES (?,?,?)");
ps.setInt (1,12);
ps.setString (2,"Oracle");
ps.setString (3,"USA");
```

2. Cast your prepared statement to an `OraclePreparedStatement` object, and apply the `setExecuteBatch()` method. In this example, the batch size of the statement is set to 2.

   ```
   ((OraclePreparedStatement)ps).setExecuteBatch(2);
   ```

   If you wish, insert the `getExecuteBatch()` method at any point in the program to check the default batch value for the statement:

   ```
   System.out.println (" Statement Execute Batch Value " +
                       ((OraclePreparedStatement)ps).getExecuteBatch());
   ```

3. If you send an execute-update call to the database at this point, then no data will be sent to the database, and the call will return 0.

   ```
   // No data is sent to the database by this call to executeUpdate
   System.out.println ("Number of rows updated so far: "
                                       + ps.executeUpdate ());
   ```

4. If you enter a set of input values for a second row and an execute-update, then the number of batch calls to `executeUpdate()` will be equal to the batch value of 2. The data will be sent to the database, and both rows will be inserted in a single round trip.

   ```
   ps.setInt (1, 11);
   ps.setString (2, "Applications");
   ps.setString (3, "Indonesia");

   int rows = ps.executeUpdate ();
   System.out.println ("Number of rows updated now: " + rows);

   ps.close ();
   ```

Checking the Batch Value

To check the overall connection batch value of an Oracle connection instance, use the `OracleConnection` class `getDefaultExecuteBatch()` method:

```
Integer batch_val = ((OracleConnection)conn).getDefaultExecuteBatch();
```

To check the particular statement batch value of an Oracle prepared statement, use the `OraclePreparedStatement` class `getExecuteBatch()` method:

```
Integer batch_val = ((OraclePreparedStatement)ps).getExecuteBatch();
```

> **Note:** If no statement batch value has been set, then `getExecuteBatch()` will return the connection batch value.

Overriding the Batch Value

If you want to execute accumulated operations before the batch value in effect is reached, then use the `sendBatch()` method of the `OraclePreparedStatement` object.

For this example, presume you set the connection batch value to 20. (This sets the default batch value for all prepared statement objects associated with the connection to 20.) You could accomplish this by casting your connection to an `OracleConnection`

object and applying the `setDefaultExecuteBatch()` method for the connection, as follows:

```
((OracleConnection)conn).setDefaultExecuteBatch (20);
```

Override the batch value as follows:

1. Write your prepared statement and specify input values for the first row as usual, then execute the statement:

   ```
   PreparedStatement ps =
      conn.prepareStatement ("insert into dept values (?, ?, ?)");

   ps.setInt (1, 32);
   ps.setString (2, "Oracle");
   ps.setString (3, "USA");

   System.out.println (ps.executeUpdate ());
   ```

   The batch is not executed at this point. The `ps.executeUpdate()` method returns "0".

2. If you enter a set of input values for a second operation and call `executeUpdate()` again, the data will still not be sent to the database, because the batch value in effect for the statement is the connection batch value: 20.

   ```
   ps.setInt (1, 33);
   ps.setString (2, "Applications");
   ps.setString (3, "Indonesia");

   // this batch is still not executed at this point
   int rows = ps.executeUpdate ();

   System.out.println ("Number of rows updated before calling sendBatch: "
                           + rows);
   ```

   Note that the value of `rows` in the `println` statement is "0".

3. If you apply the `sendBatch()` method at this point, then the two previously batched operations will be sent to the database in a single round trip. The `sendBatch()` method also returns the total number of updated rows. This property of `sendBatch()` is used by `println` to print the number of updated rows.

   ```
   // Execution of both previously batched executes will happen
   // at this point. The number of rows updated will be
   // returned by sendBatch.
   rows = ((OraclePreparedStatement)ps).sendBatch ();

   System.out.println ("Number of rows updated by calling sendBatch: "
                           + rows);
   ps.close ();
   ```

Committing the Changes in Oracle Batching

After you execute the batch, you must still commit the changes, presuming auto-commit is disabled as recommended.

Calling `commit()` on the connection object in Oracle batching not only commits operations in batches that have been executed, but also issues an implicit

`sendBatch()` call to execute all pending batches. So `commit()` effectively commits changes for all operations that have been added to a batch.

Update Counts in Oracle Batching

In a non-batching situation, the `executeUpdate()` method of an `OraclePreparedStatement` object will return the number of database rows affected by the operation.

In an Oracle batching situation, this method returns the number of rows affected at the time the method is invoked, as follows:

- If an `executeUpdate()` call results in the operation being added to the batch, then the method returns a value of 0, because nothing was written to the database yet.
- If an `executeUpdate()` call results in the batch value being reached and the batch being executed, then the method will return the total number of rows affected by all operations in the batch.

Similarly, the `sendBatch()` method of an `OraclePreparedStatement` object returns the total number of rows affected by all operations in the batch.

Example 22–1 Oracle Update Batching

The following example illustrates how you use the Oracle update batching feature. It assumes you have imported the `oracle.driver.*` interfaces.

```
...
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:oci);
ods.setUser("scott");
ods.setPassword("tiger");

Connection conn = ods.getConnection();
conn.setAutoCommit(false);

PreparedStatement ps =
  conn.prepareStatement("insert into dept values (?, ?, ?)");

//Change batch size for this statement to 3
((OraclePreparedStatement)ps).setExecuteBatch (3);

ps.setInt(1, 23);
ps.setString(2, "Sales");
ps.setString(3, "USA");
ps.executeUpdate(); //JDBC queues this for later execution

ps.setInt(1, 24);
ps.setString(2, "Blue Sky");
ps.setString(3, "Montana");
ps.executeUpdate(); //JDBC queues this for later execution

ps.setInt(1, 25);
ps.setString(2, "Applications");
ps.setString(3, "India");
ps.executeUpdate(); //The queue size equals the batch value of 3
                    //JDBC sends the requests to the database

ps.setInt(1, 26);
ps.setString(2, "HR");
```

```
ps.setString(3, "Mongolia");
ps.executeUpdate(); //JDBC queues this for later execution

((OraclePreparedStatement)ps).sendBatch(); // JDBC sends the queued request
conn.commit();

ps.close();
...
```

Note: Updates deferred through batching can affect the results of other queries. In the following example, if the first query is deferred due to batching, then the second will return unexpected results:

```
UPDATE emp SET name = "Sue" WHERE name = "Bob";
SELECT name FROM emp WHERE name = "Sue";
```

Standard Update Batching

Oracle implements the standard update batching model according to the Sun Microsystems JDBC 2.0 Specification.

This model, unlike the Oracle update batching model, depends on explicitly adding statements to the batch using an `addBatch()` method and explicitly executing the batch using an `executeBatch()` method. (In the Oracle model, you invoke `executeUpdate()` as in a non-batching situation, but whether an operation is added to the batch or the whole batch is executed is typically determined implicitly, depending on whether a pre-determined batch value is reached.)

Notes:

- Do not mix standard update batching syntax with Oracle update batching syntax in the same application. The Oracle JDBC driver will throw exceptions when these syntaxes are mixed.
- Disable auto-commit mode if you use either update batching model. In case an error occurs while you are executing a batch, this allows you the option of committing or rolling back the operations that executed successfully prior to the error.

Limitations in the Oracle Implementation of Standard Batching

Note the following limitations and implementation details regarding Oracle's implementation of standard update batching:

- In Oracle JDBC applications, update batching is intended for use with prepared statements that are being executed repeatedly with different sets of bind values.

  The Oracle implementation of standard update batching does not implement true batching for generic statements and callable statements. Even though Oracle JDBC supports the use of standard batching syntax for `Statement` and `CallableStatement` objects, you are unlikely to see performance improvement.
- Oracle's implementation of standard update batching does not support stream types as bind values. (This is also true of Oracle update batching.) Any attempt to use stream types will result in an exception.

Adding Operations to the Batch

When any statement object is first created, its statement batch is empty. Use the standard `addBatch()` method to add an operation to the statement batch. This method is specified in the standard `java.sql.Statement`, `PreparedStatement`, and `CallableStatement` interfaces, which are implemented by interfaces `oracle.jdbc.OracleStatement`, `OraclePreparedStatement`, and `OracleCallableStatement`, respectively.

For a `Statement` object (or `OracleStatement`), the `addBatch()` method takes a Java string with a SQL operation as input. For example (assume a `Connection` instance `conn`):

```
...
Statement stmt = conn.createStatement();

stmt.addBatch("INSERT INTO emp VALUES(1000, 'Joe Jones')");
stmt.addBatch("INSERT INTO dept VALUES(260, 'Sales')");
stmt.addBatch("INSERT INTO emp_dept VALUES(1000, 260)");
...
```

At this point, three operations are in the batch.

(Remember, however, that in the Oracle implementation of standard update batching, you will probably see no performance improvement in batching generic statements.)

For prepared statements, update batching is used to batch multiple executions of the same statement with different sets of bind parameters. For a `PreparedStatement` or `OraclePreparedStatement` object, the `addBatch()` method takes no input—it simply adds the operation to the batch using the bind parameters last set by the appropriate `setXXX()` methods. (This is also true for `CallableStatement` or `OracleCallableStatement` objects, but remember that in the Oracle implementation of standard update batching, you will probably see no performance improvement in batching callable statements.)

For example (again assuming a `Connection` instance `conn`):

```
...
PreparedStatement pstmt =
          conn.prepareStatement("INSERT INTO employees VALUES(?, ?)");

pstmt.setInt(1, 2000);
pstmt.setString(2, "Milo Mumford");
pstmt.addBatch();

pstmt.setInt(1, 3000);
pstmt.setString(2, "Sulu Simpson");
pstmt.addBatch();
...
```

At this point, two operations are in the batch.

Because a batch is associated with a single prepared statement object, you can batch only repeated executions of a single prepared statement, as in this example.

Executing the Batch

To execute the current batch of operations, use the `executeBatch()` method of the statement object. This method is specified in the standard `Statement` interface, which is extended by the standard `PreparedStatement` and `CallableStatement` interfaces.

Following is an example that repeats the prepared statement `addBatch()` calls shown previously and then executes the batch:

```
...
PreparedStatement pstmt =
         conn.prepareStatement("INSERT INTO employees VALUES(?, ?)");

pstmt.setInt(1, 2000);
pstmt.setString(2, "Milo Mumford");
pstmt.addBatch();

pstmt.setInt(1, 3000);
pstmt.setString(2, "Sulu Simpson");
pstmt.addBatch();

int[] updateCounts = pstmt.executeBatch();
...
```

The `executeBatch()` method returns an `int` array, typically one element per batched operation, indicating success or failure in executing the batch and sometimes containing information about the number of rows affected. This is discussed in "Update Counts in the Oracle Implementation of Standard Batching" on page 22-11.

Notes:

- After calling `addBatch()`, you must call either `executeBatch()` or `clearBatch()` before a call to `executeUpdate()`, otherwise there will be a SQL exception.
- When a batch is executed, operations are performed in the order in which they were batched.
- The statement batch is reset to empty once `executeBatch()` has returned.
- An `executeBatch()` call closes the statement object's current result set, if one exists.

Committing the Changes in the Oracle Implementation of Standard Batching

After you execute the batch, you must still commit the changes, presuming auto-commit is disabled as recommended.

Calling `commit()` commits non-batched operations and commits batched operations for statement batches that have been executed, but for the Oracle implementation of standard batching, has no effect on pending statement batches that have *not* been executed.

Clearing the Batch

To clear the current batch of operations instead of executing it, use the `clearBatch()` method of the statement object. This method is specified in the standard `Statement` interface, which is extended by the standard `PreparedStatement` and `CallableStatement` interfaces.

Following is an example that repeats the prepared statement `addBatch()` calls shown previously but then clears the batch under certain circumstances:

```
...
PreparedStatement pstmt =
         conn.prepareStatement("INSERT INTO employees VALUES(?, ?)");
```

```
pstmt.setInt(1, 2000);
pstmt.setString(2, "Milo Mumford");
pstmt.addBatch();

pstmt.setInt(1, 3000);
pstmt.setString(2, "Sulu Simpson");
pstmt.addBatch();

if (...condition...)
{
   int[] updateCounts = pstmt.executeBatch();
   ...
}
else
{
   pstmt.clearBatch();
   ...
}
```

Notes:

- After calling `addBatch()`, you must call either `executeBatch()` or `clearBatch()` before a call to `executeUpdate()`, otherwise there will be a SQL exception.
- A `clearBatch()` call resets the statement batch to empty.
- Nothing is returned by the `clearBatch()` method.

Update Counts in the Oracle Implementation of Standard Batching

If a statement batch is executed successfully (no batch exception is thrown), then the integer array—or *update counts* array—returned by the statement `executeBatch()` call will always have one element for each operation in the batch. In the Oracle implementation of standard update batching, the values of the array elements are as follows:

- For a prepared statement batch, it is not possible to know the number of rows affected in the database by each individual statement in the batch. Therefore, all array elements have a value of -2. According to the JDBC 2.0 specification, a value of -2 indicates that the operation was successful but the number of rows affected is unknown.
- For a generic statement batch or callable statement batch, the array contains the actual update counts indicating the number of rows affected by each operation. The actual update counts can be provided because Oracle JDBC cannot use true batching for generic and callable statements in the Oracle implementation of standard update batching.

In your code, upon successful execution of a batch, you should be prepared to handle either -2's or true update counts in the array elements. For a successful batch execution, the array contains either all -2's or all positive integers.

Note: For information about possible values in the update counts array for an *unsuccessful* batch execution, see "Error Handling in the Oracle Implementation of Standard Batching" on page 22-12.

Example 22–2 Standard Update Batching

This example combines the sample fragments in the previous sections, accomplishing the following steps:

- disabling auto-commit mode (which you should always do when using either update batching model)
- creating a prepared statement object
- adding operations to the batch associated with the prepared statement object
- executing the batch
- committing the operations from the batch

Assume a `Connection` instance `conn`:

```
conn.setAutoCommit(false);

PreparedStatement pstmt =
         conn.prepareStatement("INSERT INTO employees VALUES(?, ?)");

pstmt.setInt(1, 2000);
pstmt.setString(2, "Milo Mumford");
pstmt.addBatch();

pstmt.setInt(1, 3000);
pstmt.setString(2, "Sulu Simpson");
pstmt.addBatch();

int[] updateCounts = pstmt.executeBatch();

conn.commit();

pstmt.close();
...
```

You can process the update counts array to determine if the batch executed successfully. This is discussed in the next section ("Error Handling in the Oracle Implementation of Standard Batching").

Error Handling in the Oracle Implementation of Standard Batching

If any one of the batched operations fails to complete successfully (or attempts to return a result set) during an `executeBatch()` call, then execution stops and a `java.sql.BatchUpdateException` is generated (a subclass of `java.sql.SQLException`).

After a batch exception, the update counts array can be retrieved using the `getUpdateCounts()` method of the `BatchUpdateException` object. This returns an `int` array of update counts, just as the `executeBatch()` method does. In the Oracle implementation of standard update batching, contents of the update counts array are as follows after a batch exception:

- For a prepared statement batch, it is not possible to know which operation failed. The array has one element for each operation in the batch, and each element has a value of -3. According to the JDBC 2.0 specification, a value of -3 indicates that an operation did not complete successfully. In this case, it was presumably just one operation that actually failed, but because the JDBC driver does not know which operation that was, it labels all the batched operations as failures.

  You should always perform a `ROLLBACK` operation in this situation.

- For a generic statement batch or callable statement batch, the update counts array is only a partial array containing the actual update counts up to the point of the error. The actual update counts can be provided because Oracle JDBC cannot use true batching for generic and callable statements in the Oracle implementation of standard update batching.

  For example, if there were 20 operations in the batch, the first 13 succeeded, and the 14th generated an exception, then the update counts array will have 13 elements, containing actual update counts of the successful operations.

  You can either commit or roll back the successful operations in this situation, as you prefer.

In your code, upon failed execution of a batch, you should be prepared to handle either -3's or true update counts in the array elements when an exception occurs. For a failed batch execution, you will have either a full array of -3's or a partial array of positive integers.

Intermixing Batched Statements and Non-Batched Statements

You cannot call `executeUpdate()` for regular, non-batched execution of an operation if the statement object has a pending batch of operations (essentially, if the batch associated with that statement object is non-empty).

You can, however, intermix batched operations and non-batched operations in a single statement object if you execute non-batched operations either prior to adding any operations to the statement batch or after executing the batch. Essentially, you can call `executeUpdate()` for a statement object only when its update batch is empty. If the batch is non-empty, then an exception will be generated.

For example, it is legal to have a sequence such as the following:

```
...
PreparedStatement pstmt =
          conn.prepareStatement("INSERT INTO employees VALUES(?, ?)");

pstmt.setInt(1, 2000);
pstmt.setString(2, "Milo Mumford");

int scount = pstmt.executeUpdate();   // OK; no operations in pstmt batch

pstmt.setInt(1, 3000);
pstmt.setString(2, "Sulu Simpson");
pstmt.addBatch();                    // Now start a batch

pstmt.setInt(1, 4000);
pstmt.setString(2, "Stan Leland");
pstmt.addBatch();

int[] bcounts = pstmt.executeBatch();

pstmt.setInt(1, 5000);
pstmt.setString(2, "Amy Feiner");

int scount = pstmt.executeUpdate();   // OK; pstmt batch was executed
...
```

Intermixing non-batched operations on one statement object and batched operations on another statement object within your code is permissible. Different statement objects are independent of each other with regards to update batching operations. A

COMMIT request will affect all non-batched operations and all successful operations in executed batches, but will not affect any pending batches.

Premature Batch Flush

Premature batch flush happens due to a change in cached metadata. Cached metadata can be changed due to various reasons, such as the following:

- The initial bind was null and the following bind is not null
- A scalar type is initially bound as string and then bound as scalar type or the reverse

The premature batch flush count is summed to the return value of the next `executeUpdate()` or `sendBatch()` method.

The old functionality lost all these batch flush values which can be obtained now. To switch back to the old functionality, you can set the `AccumulateBatchResult` property to `false`, as shown below:

```
java.util.Properties info = new java.util.Properties();
info.setProperty("user", "SCOTT");
info.setProperty("passwd", "TIGER");
// other properties
...

// property: batch flush type
info.setProperty("AccumulateBatchResult", "false");

OracleDataSource ods = new OracleDataSource();
ods.setConnectionProperties(info);
ods.setURL("jdbc:oracle:oci:@"");
Connection conn = ods.getConnection();
```

> **Note:** The `AccumulateBatchResult` property is set to `true` by default.

Example 22–3 Premature Batch Flushing

```
((OraclePreparedStatement)pstmt).setExecuteBatch (2);

pstmt.setNull (1, OracleTypes.NUMBER);
pstmt.setString (2, "test11");
int count = pstmt.executeUpdate (); // returns 0

/*
* Premature batch flush happens here.
*/
pstmt.setInt (1, 22);
pstmt.setString (2, "test22");
int count = pstmt.executeUpdate (); // returns 0

pstmt.setInt (1, 33);
pstmt.setString (2, "test33");
/*
*  returns 3 with the new batching scheme where as,
*  returns 2 with the old batching scheme.
*/
int count = pstmt.executeUpdate ();
```

Additional Oracle Performance Extensions

In addition to update batching, discussed previously, Oracle JDBC drivers support the following extensions that improve performance by reducing round trips to the database:

- prefetching rows

  This reduces round trips to the database by fetching multiple rows of data each time data is fetched—the extra data is stored in client-side buffers for later access by the client. The number of rows to prefetch can be set as desired.

- specifying column types

  This avoids an inefficiency in the normal JDBC protocol for performing and returning the results of queries.

- suppressing database metadata `TABLE_REMARKS` columns

  This avoids an expensive outer join operation.

Oracle provides several extensions to connection properties objects to support these performance extensions. These extensions enable you to set the `remarksReporting` flag and default values for row prefetching and update batching. For more information, see "Supported Connection Properties" on page 4-3.

Oracle Row Prefetching

Oracle JDBC drivers include extensions that allow you to set the number of rows to prefetch into the client while a result set is being populated during a query. This feature reduces the number of round trips to the server.

> **Note:** With JDBC 2.0, the ability to preset the fetch size became standard functionality. For information about the standard implementation of this feature, see "Fetch Size" on page 17-15.

Setting the Oracle Prefetch Value

Standard JDBC receives the result set one row at a time, and each row requires a round trip to the database. The row-prefetching feature associates an integer row-prefetch setting with a given statement object. JDBC fetches that number of rows at a time from the database during the query. That is, JDBC will fetch N rows that match the query criteria and bring them all back to the client at once, where N is the prefetch setting. Then, once your `next()` calls have run through those N rows, JDBC will go back to fetch the next N rows that match the criteria.

You can set the number of rows to prefetch for a particular Oracle statement (any type of statement). You can also reset the default number of rows that will be prefetched for all statements in your connection. The default number of rows to prefetch to the client is 10.

Set the number of rows to prefetch for a particular statement as follows:

1. Cast your statement object to an `OracleStatement`, `OraclePreparedStatement`, or `OracleCallableStatement` object, as applicable, if it is not already one of these.
2. Use the `setRowPrefetch()` method of the statement object to specify the number of rows to prefetch, passing in the number as an integer. If you want to check the current prefetch number, use the `getRowPrefetch()` method of the Statement object, which returns an integer.

Set the default number of rows to prefetch for all statements in a connection, as follows:

1. Cast your `Connection` object to an `OracleConnection` object.
2. Use the `setDefaultRowPrefetch()` method of your `OracleConnection` object to set the default number of rows to prefetch, passing in an integer that specifies the desired default. If you want to check the current setting of the default, then use the `getDefaultRowPrefetch()` method of the `OracleConnection` object. This method returns an integer.

   Equivalently, instead of calling `setDefaultRowPrefetch()`, you can set the `defaultRowPrefetch` Java property if you use a Java `Properties` object in establishing the connection. See "Supported Connection Properties" on page 4-3.

Notes:

- Do not mix the JDBC 2.0 fetch size API and the Oracle row-prefetching API in your application. You can use one or the other, but not both.
- Be aware that setting the Oracle row-prefetch value can affect not only queries, but also: 1) explicitly refetching rows in a result set through the result set `refreshRow()` method available with JDBC 2.0 (relevant for scroll-sensitive/read-only, scroll-sensitive/updatable, and scroll-insensitive/updatable result sets); and 2) the "window" size of a scroll-sensitive result set, affecting how often automatic refetches are performed. The Oracle row-prefetch value will be overridden, however, by any setting of the fetch size. See "Fetch Size" on page 17-15 for more information.

Example 22–4 Row Prefetching

The following example illustrates the row-prefetching feature. It assumes you have imported the `oracle.jdbc.*` interfaces.

```
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:oci:");
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();

//Set the default row-prefetch setting for this connection
((OracleConnection)conn).setDefaultRowPrefetch(7);

/* The following statement gets the default row-prefetch value for
   the connection, that is, 7.
 */
```

```
Statement stmt = conn.createStatement();

/* Subsequent statements look the same, regardless of the row
   prefetch value. Only execution time changes.
 */
ResultSet rset = stmt.executeQuery("SELECT ename FROM emp");
System.out.println( rset.next () );

while( rset.next () )
    System.out.println( rset.getString (1) );

//Override the default row-prefetch setting for this statement
( (OracleStatement)stmt ).setRowPrefetch (2);

ResultSet rset = stmt.executeQuery("SELECT ename FROM emp");
System.out.println( rset.next () );

while( rset.next() )
   System.out.println( rset.getString (1) );

stmt.close();
```

Oracle Row-Prefetching Limitations

There is no maximum prefetch setting, but empirical evidence suggests that 10 is effective. Oracle does not recommend exceeding this value in most situations. If you do not set the default row-prefetch value for a connection, 10 is the default.

A statement object receives the default row-prefetch setting from the associated connection at the time the statement object is created. Subsequent changes to the connection's default row-prefetch setting have no effect on the statement's row-prefetch setting.

If a column of a result set is of datatype `LONG` or `LONG RAW` (that is, the streaming types), JDBC changes the statement's row-prefetch setting to 1, even if you never actually read a value of either of those types.

You can set the connection's default row-prefetch value using a Properties object. See "Supported Connection Properties" on page 4-3.

Defining Column Types

The implementation of `defineColumnType()` has changed significantly. at 10*g* Release 1 (10.1). Previously, `defineColumnType()` was used both as a performance optimization and to force datatype conversion. The revised implementation has no performance impact, except that you can use the maximum field size argument to control how much memory the client side allocates.

It is no longer necessary to call `defineColumnType()` on all the columns retrieved in a result set.

Previous versions of the JDBC drivers performed type conversion on the client side; at this release, type conversion is performed on the server side.

From the server point of view, a `defineColumnType()` invocation which does not perform a datatype conversion has no impact. It is purely a client-side API which can be used to allocate less memory.

Follow these general steps to define column types for a query:

1. If necessary, cast your statement object to an `OracleStatement`, `OraclePreparedStatement`, or `OracleCallableStatement` object, as applicable.
2. If necessary, use the `clearDefines()` method of your `Statement` object to clear any previous column definitions for this `Statement` object.
3. On each character column, invoke the `defineColumnType()` method of your `Statement` object, passing it these parameters:
   - column index (integer)
   - typecode (integer)

     Use the static constants of the `java.sql.Types` class or `oracle.jdbc.OracleTypes` class (such as `Types.INTEGER`, `Types.FLOAT`, `Types.VARCHAR`, `OracleTypes.VARCHAR`, and `OracleTypes.ROWID`). Typecodes for standard types are identical in these two classes.
   - type name (string) (structured objects, object references, and arrays only)

     For structured objects, object references, and arrays, you must also specify the type name (for example, `Employee`, `EmployeeRef`, or `EmployeeArray`).
   - (optionally) maximum field size (integer)

     Optionally specify a maximum data length for this column.

     You cannot specify a maximum field size parameter if you are defining the column type for a structured object, object reference, or array. If you try to include this parameter, it will be ignored.
   - (optionally) form-of-use (short)

     Optionally specify a form of use for the column. This can be `OraclePreparedStatement.FORM_CHAR` to use the database character set or `OraclePreparedStatement.FORM_NCHAR` to use the national character set. If this parameter is omitted, the default is `FORM_CHAR`.

   For example, assuming `stmt` is an Oracle statement, use this syntax:

   ```
   stmt.defineColumnType(column_index, typeCode);
   ```

   or, if the column is `VARCHAR` or equivalent and you know the length limit:

   ```
   stmt.defineColumnType(column_index, typeCode, max_size);
   ```

   or, for an `NVARCHAR` column where the original maximum length is desired and conversion to the database character set is requested:

   ```
   stmt.defineColumnType(column_index, typeCode, 0,
      OraclePreparedStatement.FORM_CHAR );
   ```

   or, for structured object, object reference, and array columns:

   ```
   stmt.defineColumnType(column_index, typeCode, typeName);
   ```

   Set a maximum field size if you do not want to receive the full default length of the data. Calling the `setMaxFieldSize()` method of the standard JDBC `Statement` class sets a restriction on the amount of data returned. Specifically, the size of the data returned will be the minimum of:

- the maximum field size set in `defineColumnType()`

or:

- the maximum field size set in `setMaxFieldSize()`

or:

- the natural maximum size of the datatype

After you complete these steps, use the statement's `executeQuery()` method to perform the query.

> **Note:** It is no longer necessary to specify a datatype for each column of the expected result set.

The following example illustrates the use of this feature. It assumes you have imported the `oracle.jdbc.*` interfaces.

Example 22–5 Defining Column Types

```
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:thin:@localhost:1502:orcl");
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();

Statement stmt = conn.createStatement();
// Allocate only 2 chars for this column (truncation will happen)
((OracleStatement)stmt).defineColumnType(1, Types.VARCHAR, 2);
ResultSet rset = stmt.executeQuery("select ename from emp");
while (rset.next() )
  System.out.println(rset.getString(1));
stmt.close();
```

As this example shows, you must cast the statement (`stmt`) to type `OracleStatement` in the invocation of the `defineColumnType()` method. The connection's `createStatement()` method returns an object of type `java.sql.Statement`, which does not have the `defineColumnType()` and `clearDefines()` methods. These methods are provided only in the `OracleStatement` implementation.

The define-extensions use JDBC types to specify the desired types. The allowed define types for columns depend on the internal Oracle type of the column.

All columns can be defined to their "natural" JDBC types; in most cases, they can be defined to the `Types.CHAR` or `Types.VARCHAR` typecode.

Table 22–1 lists the valid column definition arguments you can use in the `defineColumnType()` method.

Table 22–1 Valid Column Type Specifications

If the column has Oracle SQL type:	You can use defineColumnType() to define it as:
NUMBER, VARNUM	BIGINT, TINYINT, SMALLINT, INTEGER, FLOAT, REAL, DOUBLE, NUMERIC, DECIMAL, CHAR, VARCHAR
CHAR, VARCHAR2	CHAR, VARCHAR
LONG	CHAR, VARCHAR, LONGVARCHAR
LONGRAW	LONGVARBINARY, VARBINARY, BINARY
RAW	VARBINARY, BINARY
DATE	DATE, TIME, TIMESTAMP, CHAR, VARCHAR
ROWID	ROWID
BLOB	VARBINARY, BINARY
CLOB	LONG, CHAR, VARCHAR

It is always valid to use `defineColumnType()` with the original datatype of the column. Because it is no longer required to use `defineColumnType()` on all columns, it is not necessary to do so.

DatabaseMetaData TABLE_REMARKS Reporting

The `getColumns()`, `getProcedureColumns()`, `getProcedures()`, and `getTables()` methods of the database metadata classes are slow if they must report `TABLE_REMARKS` columns, because this necessitates an expensive outer join. For this reason, the JDBC driver does *not* report `TABLE_REMARKS` columns by default.

You can enable `TABLE_REMARKS` reporting by passing a `true` argument to the `setRemarksReporting()` method of an `OracleConnection` object.

Equivalently, instead of calling `setRemarksReporting()`, you can set the `remarksReporting` Java property if you use a Java `Properties` object in establishing the connection. See "Supported Connection Properties" on page 4-3.

If you are using a standard `java.sql.Connection` object, you must cast it to `OracleConnection` to use `setRemarksReporting()`.

Example 22–6 TABLE_REMARKS Reporting

Assuming `conn` is the name of your standard `Connection` object, the following statement enables `TABLE_REMARKS` reporting.

```
( (oracle.jdbc.OracleConnection)conn ).setRemarksReporting(true);
```

Considerations for getProcedures() and getProcedureColumns() Methods

According to JDBC versions 1.1 and 1.2, the methods `getProcedures()` and `getProcedureColumns()` treat the `catalog`, `schemaPattern`, `columnNamePattern`, and `procedureNamePattern` parameters in the same way. In the Oracle definition of these methods, the parameters are treated differently:

- `catalog`: Oracle does not have multiple catalogs, but it does have packages. Consequently, the `catalog` parameter is treated as the package name. This applies both on input (the `catalog` parameter) and output (the `catalog` column in the returned `ResultSet`). On input, the construct `" "` (the empty string)

retrieves procedures and arguments without a package, that is, standalone objects. A `null` value means to drop from the selection criteria, that is, return information about both stand-alone and packaged objects (same as passing in "`%`"). Otherwise the `catalog` parameter should be a package name pattern (with SQL wild cards, if desired).

- `schemaPattern`: All objects within Oracle must have a schema, so it does not make sense to return information for those objects without one. Thus, the construct `" "` (the empty string) is interpreted on input to mean the objects in the current schema (that is, the one to which you are currently connected). To be consistent with the behavior of the `catalog` parameter, `null` is interpreted to drop the schema from the selection criteria (same as passing in "`%`"). It can also be used as a pattern with SQL wild cards.
- `procedureNamePattern` and `columnNamePattern`: The empty string (" ") does not make sense for either parameter, because all procedures and arguments must have names. Thus, the construct `" "` will raise an exception. To be consistent with the behavior of other parameters, `null` has the same effect as passing in "`%`".

23

Advanced Topics

This chapter describes the following advanced JDBC topics:

- JDBC Client-Side Security Features
- JDBC in Applets
- JDBC in the Server: the Server-Side Internal Driver

JDBC Client-Side Security Features

This section discusses support in the Oracle JDBC OCI and Thin drivers for login authentication, data encryption, and data integrity—particularly with respect to features of the Oracle Advanced Security option.

Oracle Advanced Security, previously known as the "Advanced Networking Option" (ANO) or "Advanced Security Option" (ASO), includes features to support data encryption, data integrity, third-party authentication, and authorizations. Oracle JDBC supports most of these features; however, the JDBC Thin driver must be considered separately from the JDBC OCI driver.

> **Note:** This discussion is not relevant to the server-side internal driver, given that all communication through that driver is completely internal to the server.

JDBC Support for Oracle Advanced Security

Both the JDBC OCI drivers and the JDBC Thin driver support at least some of the features of Oracle Advanced Security. If you are using one of the OCI drivers, you can set relevant parameters in the same way that you would in any thick-client setting. The Thin driver supports Advanced Security features through a set of Java classes included with the JDBC classes JAR file, and supports security parameter settings through Java properties objects.

Included in your Oracle JDBC `classes12.jar` file is a JAR file containing classes that incorporate features of Oracle Advanced Security, and a JAR file containing classes whose function is to interface between the JDBC classes and the Advanced Security classes for use with the JDBC Thin driver.

OCI Driver Support for Oracle Advanced Security

If you are using one of the JDBC OCI drivers, which presumes you are running from a thick-client machine with an Oracle client installation, then support for Oracle Advanced Security and incorporated third-party features is, for the most part, no

different from any Oracle thick-client situation. Your use of Advanced Security features is determined by related settings in the `SQLNET.ORA` file on the client machine, as discussed in the *Oracle Advanced Security Administrator's Guide*. Refer to that manual for information.

> **Important:** The one key exception to the preceding, with respect to Java, is that SSL—Sun Microsystem's standard Secure Socket Layer protocol—is supported by the Oracle JDBC OCI drivers only if you use native threads in your application. This requires special attention, because green threads are generally the default.

Thin Driver Support for Oracle Advanced Security

Because the Thin driver was designed to be downloadable with applets, one obviously cannot assume that there is an Oracle client installation and a `SQLNET.ORA` file where the Thin driver is used. This necessitated the design of a new, 100% Java approach to Oracle Advanced Security support.

Java classes that implement Oracle Advanced Security are included in your JDBC `classes12.jar` file. Security parameters for encryption and integrity, normally set in `SQLNET.ORA`, are set in a Java properties file instead.

For information about parameter settings, see "Thin Driver Support for Encryption and Integrity" on page 23-4.

JDBC Support for Login Authentication

Basic login authentication through JDBC consists of user names and passwords, as with any other means of logging in to an Oracle server. Specify the user name and password through a Java properties object or directly through the `getConnection()` method call, as discussed in "Opening a Connection to a Database" on page 4-2.

This applies regardless of which client-side Oracle JDBC driver you are using, but is irrelevant if you are using the server-side internal driver, which uses a special direct connection and does not require a user name or password.

The Oracle JDBC Thin driver implements Oracle O3LOGON challenge-response protocol to authenticate the user.

> **Note:** Third-party authentication features supported by Oracle Advanced Security—such as those provided by RADIUS, Kerberos, or SecurID—are not supported by the Oracle JDBC Thin driver. For the Oracle JDBC OCI driver, support is the same as in any thick-client situation—refer to the *Oracle Advanced Security Administrator's Guide*.

JDBC Support for Data Encryption and Integrity

You can use Oracle Advanced Security data encryption and integrity features in your Java database applications, depending on related settings in the server.

When using an OCI driver in a thick-client setting, set parameters as you would in any Oracle client situation. When using the Thin driver, set parameters through a Java properties file.

Encryption is enabled or disabled based on a combination of the client-side encryption-level setting and the server-side encryption-level setting.

Similarly, integrity is enabled or disabled based on a combination of the client-side integrity-level setting and the server-side integrity-level setting.

Encryption and integrity support the same setting levels—`REJECTED`, `ACCEPTED`, `REQUESTED`, and `REQUIRED`. Table 23–1 shows how these possible settings on the client-side and server-side combine to either enable or disable the feature.

Table 23–1 Client/Server Negotiations for Encryption or Integrity

	Client Rejected	Client Accepted (default)	Client Requested	Client Required
Server Rejected	OFF	OFF	OFF	connection fails
Server Accepted (default)	OFF	OFF	ON	ON
Server Requested	OFF	ON	ON	ON
Server Required	connection fails	ON	ON	ON

This table shows, for example, that if encryption is requested by the client, but rejected by the server, it is disabled. The same is true for integrity. As another example, if encryption is accepted by the client and requested by the server, it is enabled. And, again, the same is true for integrity.

The general settings are further discussed in the *Oracle Advanced Security Administrator's Guide*. How to set them for a JDBC application is described in the following subsections.

> **Note:** The term "checksum" still appears in integrity parameter names, as you will see in the following subsections, but is no longer used otherwise. For all intents and purposes, "checksum" and "integrity" are synonymous.

OCI Driver Support for Encryption and Integrity

If you are using one of the Oracle JDBC OCI drivers, which presumes a thick-client setting with an Oracle client installation, you can enable or disable data encryption or integrity and set related parameters as you would in any Oracle client situation, through settings in the `SQLNET.ORA` file on the client machine.

To summarize, the client parameters are shown in Table 23–2:

Table 23–2 OCI Driver Client Parameters for Encryption and Integrity

Parameter Description	Parameter Name	Possible Settings
Client encryption level	SQLNET.ENCRYPTION_CLIENT	REJECTED ACCEPTED REQUESTED REQUIRED
Client encryption selected list	SQLNET.ENCRYPTION_TYPES_CLIENT	RC4_40,RC4_56, DES,DES40, AES128,AES192, AES256,3DES112, 3DES168 (see note below)
Client integrity level	SQLNET.CRYPTO_CHECKSUM_CLIENT	REJECTED ACCEPTED REQUESTED REQUIRED
Client integrity selected list	SQLNET.CRYPTO_CHECKSUM_TYPES_CLIENT	MD5

Note: For the Oracle Advanced Security domestic edition only, settings of `RC4_128` and `RC4_256` are also possible.

These settings, and corresponding settings in the server, are further discussed in Appendix A of the *Oracle Advanced Security Administrator's Guide*.

Thin Driver Support for Encryption and Integrity

Thin driver support for data encryption and integrity parameter settings parallels the thick-client support discussed in the preceding section. Corresponding parameters exist under the `oracle.net` package and can be set through a Java properties object that you would then use in opening your database connection.

If you replace "SQLNET" in the parameter names in Table 23–2 with "oracle.net", you will get the parameter names supported by the Thin driver (but note that in Java, the parameter names are all-lowercase).

Table 23–3 lists the parameter information for the Thin driver. See the next section for examples of how to set these parameters in Java.

Table 23–3 Thin Driver Client Parameters for Encryption and Integrity

Parameter Name	Parameter Type	Parameter Class	Possible Settings

`oracle.net.encryption_client`	string	static	`REJECTED`
			`ACCEPTED`
			`REQUESTED`
			`REQUIRED`

`oracle.net.encryption_types_client`	string	static	`RC4_40`
			`RC4_56`
			`DES40C`
			`DES56C`
			`3DES112`
			`3DES168`

`oracle.net.crypto_checksum_client`	string	static	`REJECTED`
			`ACCEPTED`
			`REQUESTED`
			`REQUIRED`

`oracle.net.crypto_checksum_types_client`	string	static	`MD5`

Notes:

- Because Oracle Advanced Security support for the Thin driver is incorporated directly into the JDBC classes JAR file, there is only one version, not separate domestic and export editions. Only parameter settings that would be suitable for an export edition are possible.
- The "C" in `3DES168` and `DES56C` refers to CBC (cipher block chaining) mode.

Setting Encryption and Integrity Parameters in Java

Use a Java properties object (`java.util.Properties`) to set the data encryption and integrity parameters supported by the Oracle JDBC Thin driver.

The following example instantiates a Java properties object, uses it to set each of the parameters in Table 23–3, and then uses the properties object in opening a connection to the database:

```
...
Properties prop = new Properties();
prop.put("oracle.net.encryption_client", "REQUIRED");
prop.put("oracle.net.encryption_types_client", "( DES40 )");
prop.put("oracle.net.crypto_checksum_client", "REQUESTED");
prop.put("oracle.net.crypto_checksum_types_client", "( MD5 )");

OracleDataSource ods = new OracleDataSource();
ods.setProperties(prop);
ods.setURL("jdbc:oracle:thin:@localhost:1521:main");
Connection conn = ods.getConnection();
...
```

The parentheses around the parameter values in the `encryption_types_client` and `crypto_checksum_types_client` settings allow for lists of values. Currently,

the Thin driver supports only one possible value in each case; however, in the future, when multiple values are supported, specifying a list will result in a negotiation between the server and the client that determines which value is actually used.

Complete example Example 23–1 is a complete class that sets data encryption and integrity parameters before connecting to a database to perform a query.

> **Note:** in this example, the string "REQUIRED" is retrieved dynamically through functionality of the `AnoServices` and `Service` classes. You have the option of retrieving the strings in this manner or hardcoding them as in the previous examples

Before running this example, you must turn on encryption in the `sqlnet.ora` file. For example, the following 4 lines will turn on DES40, DES, 2-DES-112 and 3-DES168 for the encryption and MD5 and SHA1 for the checksum:

```
SQLNET.ENCRYPTION_SERVER = ACCEPTED
SQLNET.CRYPTO_CHECKSUM_SERVER = ACCEPTED
SQLNET.CRYPTO_CHECKSUM_TYPES_SERVER= (MD5, SHA1)
SQLNET.ENCRYPTION_TYPES_SERVER= (DES40, DES, 3DES112, 3DES168)
SQLNET.CRYPTO_SEED = 12345678901234567890
```

Example 23–1 Setting Data Encryption and Integrity Parameters

```
import java.sql.*;
import java.sql.*;
import java.io.*;
import java.util.*;
import oracle.net.ns.*;
import oracle.net.ano.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.*;

class Employee
{
  public static void main (String args [])
    throws Exception
  {

    Properties props = new Properties();

    try {
      FileInputStream defaultStream = new FileInputStream(args[0]);
      props.load(defaultStream);


      int level = AnoServices.REQUIRED;
      props.put("oracle.net.encryption_client", Service.getLevelString(level));
      props.put("oracle.net.encryption_types_client", "( 3DES168 )");
      props.put("oracle.net.crypto_checksum_client",
                Service.getLevelString(level));
      props.put("oracle.net.crypto_checksum_types_client", "( MD5 )");
    } catch (Exception e) { e.printStackTrace(); }


    // You can put a database name after the @ sign in the connection URL.
    OracleDataSource ods = new OracleDataSource();
    ods.setURL("jdbc:oracle:thin:@host.example.com:1521:main");
```

```
    ods.setConnectionProperties(props);
    Connection conn = ods.getConnection();


    // Create a Statement
    Statement stmt = conn.createStatement ();

    // Select the ENAME column from the EMP table
    ResultSet rset = stmt.executeQuery ("select ENAME from EMP");

    // Iterate through the result and print the employee names
    while (rset.next ())
       System.out.println (rset.getString (1));

    conn.close();
  }

}
```

JDBC in Applets

This section describes some of the basics of working with Oracle JDBC applets.

Aside being mindful of applet connection and security issues, there is essentially no difference between coding a JDBC applet and a JDBC application.

This section describes what you must do for the applet to connect to a database, including how to use the Oracle Connection Manager or signed applets if you are connecting to a database not running on the same host as the Web server. It also describes how your applet can connect to a database through a firewall. The section concludes with how to package and deploy the applet.

The following topics are covered:

- Connecting to the Database through the Applet
- Connecting to a Database on a Different Host Than the Web Server
- Using Applets with Firewalls
- Packaging Applets
- Specifying an Applet in an HTML Page

For general information about connecting to the database, see "Opening a Connection to a Database" on page 4-2.

Connecting to the Database through the Applet

The most common task of an applet using the JDBC driver is to connect to and query a database. Because of applet security restrictions, unless particular steps are taken an applet can open TCP/IP sockets only to the host from which it was downloaded (this is the host on which the Web server is running). This means that without these steps, your applet can connect only to a database that is running on the same host as the Web server.

If your database and Web server are running on the same host, then there is no issue and no special steps are required. You can connect to the database as you would from an application.

As with connecting from an application, there are two ways in which you can specify the connection information to the driver. You can provide it in the form of `host:port:sid` or in the form of a TNS keyword-value syntax.

For example, if the database to which you want to connect resides on host `prodHost`, at port `1521`, and SID `ORCL`, and you want to connect with user name `scott` with password `tiger`, then use either of the two following connect strings:

using `host:port:sid` syntax:

```
String connString="jdbc:oracle:thin:@prodHost:1521:ORCL";

OracleDataSource ods = new OracleDataSource();
ods.setURL(connString);
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();
```

using TNS keyword-value syntax:

```
String connString = "jdbc:oracle:thin:@(description=(address_list=
   (address=(protocol=tcp)(port=1521)(host=prodHost)))
OracleDataSource ods = new OracleDataSource();

ods.setURL(connString);
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();
   (connect_data=(INSTANCE_NAME=ORCL)))";
```

If you use the TNS keyword-value pair to specify the connection information to the JDBC Thin driver, then you must declare the protocol as TCP.

However, a Web server and an Oracle database server both require many resources; you seldom find both servers running on the same machine. Usually, your applet connects to a database on a host other than the one on which the Web server runs. There are two possible ways in which you can work around the security restriction:

- You can connect to the database by using the Oracle Connection Manager.

or:

- You can use a signed applet to connect to the database directly.

These options are discussed in the next section, "Connecting to a Database on a Different Host Than the Web Server".

Connecting to a Database on a Different Host Than the Web Server

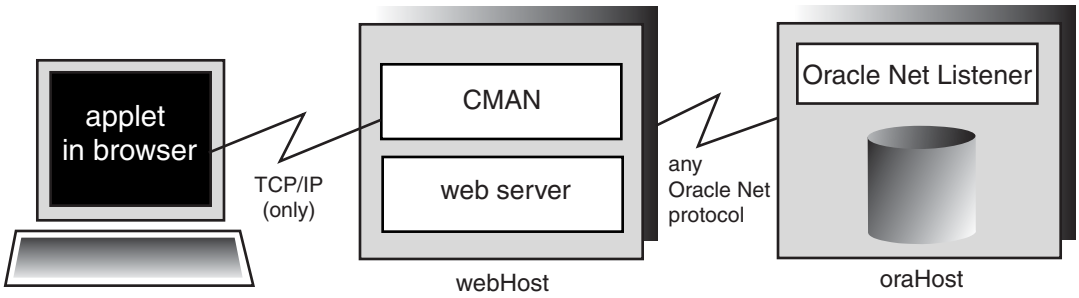
If you are connecting to a database on a host other than the one on which the Web server is running, then you must overcome applet security restrictions. You can do this by using either the Oracle Connection Manager or signed applets.

Using the Oracle Connection Manager

The Oracle Connection Manager is a lightweight, highly-scalable program that can receive Oracle Net packets and re-transmit them to a different server. To a client running Oracle Net, the Connection Manager looks exactly like a database server. An applet that uses the JDBC Thin driver can connect to a Connection Manager running on the Web server host and have the Connection Manager redirect the Oracle Net packets to an Oracle server running on a different host.

Figure 23–1 illustrates the relationship between the applet, the Oracle Connection Manager, and the database.

Figure 23–1 Applet, Connection Manager, and Database Relationship



Using the Oracle Connection Manager requires two steps:

- Install and run the Connection Manager.
- Write the connection string that targets the Connection Manager.

There is also discussion of how to connect using multiple connection managers.

Installing and Running the Oracle Connection Manager You must install the Connection Manager, available on the Oracle distribution media, onto the Web server host. You can find the installation instructions in the *Oracle Net Services Administrator's Guide*.

On the Web server host, create a `CMAN.ORA` file in the `[ORACLE_HOME]/NET8/ADMIN` directory. The options you can declare in a `CMAN.ORA` file include firewall and connection pooling support.

Here is an example of a very simple `CMAN.ORA` file. Replace *`web-server-host`* with the name of your Web server host. The fourth line in the file indicates that the Connection Manager is listening on port `1610`. You must use this port number in your connect string for JDBC.

```
cman = (ADDRESS_LIST =
       (ADDRESS = (PROTOCOL=TCP)
       (HOST=web-server-host)
       (PORT=1610)))

cman_profile = (parameter_list =
       (MAXIMUM_RELAYS=512)
       (LOG_LEVEL=1)
   (TRACING=YES)
       (RELAY_STATISTICS=YES)
       (SHOW_TNS_INFO=YES)
       (USE_ASYNC_CALL=YES)
       (AUTHENTICATION_LEVEL=0)
       )
```

Note that the Java Oracle Net version inside the JDBC Thin driver does not have authentication service support. This means that the `AUTHENTICATION_LEVEL` configuration parameter in the `CMAN.ORA` file must be set to `0`.

After you create the file, start the Connection Manager at the operating system prompt with this command:

```
cmctl start
```

To use your applet, you must now write the connect string for it.

Writing the URL that Targets the Connection Manager This section describes how to write the URL in your applet so that the applet connects to the Connection Manager, and the Connection Manager connects with the database. In the URL, you specify an address list that lists the protocol, port, and name of the Web server host on which the Connection Manager is running, followed by the protocol, port, and name of the host on which the database is running.

The following example describes the configuration illustrated in Figure 23–1. The Web server on which the Connection Manager is running is on host `webHost` and is listening on port `1610`. The database to which you want to connect is running on host `oraHost`, listening on port `1521`, and SID `ORCL`. You write the URL in TNS keyword-value format:

```
String myURL =
   "jdbc:oracle:thin:@(description=(address_list=
   (address=(protocol=tcp)(port=1610)(host=webHost))
   (address=(protocol=tcp)(port=1521)(host=oraHost)))
   (connect_data=(INSTANCE_NAME=orcl))
   (source_route=yes))";
   OracleDataSource ods = new OracleDataSource();
   ods.setURL(myURL);
   ods.setUser("scott");
   ods.setPassword("tiger");
   Connection conn = ods.getConnection();
```

The first element in the `address_list` entry represents the connection to the Connection Manager. The second element represents the database to which you want to connect. The order in which you list the addresses is important.

When your applet uses a URL such as the one above, it will behave exactly as if it were connected directly to the database on the host `oraHost`.

For more information on the parameters that you specify in the URL, see the *Oracle Net Services Administrator's Guide*.

Connecting through Multiple Connection Managers Your applet can reach its target database even if it first has to go through multiple Connection Managers (for example, if the Connection Managers form a "proxy chain"). To do this, add the addresses of the Connection Managers to the address list, in the order that you plan to access them. The database listener should be the last address on this list. See the *Oracle Net Services Administrator's Guide* for more information about `source_route` addressing.

Using Signed Applets

In a JDK 1.2.x-based or higher browser, an applet can request socket connection privileges and connect to a database running on a different host than the Web server host. In Netscape 4.0, you perform this by signing your applet (that is, writing a signed applet). You must follow these steps:

1. Sign the applet. For information on the steps you must follow to sign an applet, see Sun's *Signed Applet Example* at:

   ```
   http://java.sun.com/security/signExample/index.html
   ```

2. Include applet code that asks for appropriate permission before opening a socket.

If you are using Netscape, then your code would include a statement like this:

```
netscape.security.PrivilegeManager.enablePrivilege("UniversalConnect");
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:thin:scott/tiger@dlsun511:1721:orcl");
Connection conn = ods.getConnection();
```

3. You must obtain an object-signing certificate. See Netscape's *Object-Signing Resources* page at:

   ```
   http://developer.netscape.com/software/signedobj/index.html
   ```

This site provides information on obtaining and installing a certificate.

For more information on writing applet code that asks for permissions, see Netscape's *Introduction to Capabilities Classes* at:

```
http://developer.netscape.com/docs/manuals/signedobj/capabilities/contents.htm
```

For information about the Java Security API, including signed applet examples, see the following Sun Microsystems site:

```
http://java.sun.com/security
```

Using Applets with Firewalls

Under normal circumstances, an applet that uses the JDBC Thin driver cannot access the database through a firewall. In general, the purpose of a firewall is to prevent unauthorized clients from reaching the server. In the case of applets trying to connect to the database, the firewall prevents the opening of a TCP/IP socket to the database.

Firewalls are rule-based. They have a list of rules that define which clients can connect, and which cannot. Firewalls compare the client's hostname with the rules, and based on this comparison, either grant the client access, or not. If the hostname lookup fails, the firewall tries again. This time, the firewall extracts the IP address of the client and compares it to the rules. The firewall is designed to do this so that users can specify rules that include hostnames as well as IP addresses.

You can solve the firewall issue by using an Oracle Net-compliant firewall and connection strings that comply with the firewall configuration. Oracle Net-compliant firewalls are available from many leading vendors; a more detailed discussion of these firewalls is beyond the scope of this manual.

An unsigned applet can access only the same host from which it was downloaded. In this case, the Oracle Net-compliant firewall must be installed on that host. In contrast, a signed applet can connect to any host. In this case, the firewall on the target host controls the access.

Connecting through a firewall requires two steps, described in the following sections:

- Configuring a Firewall for Applets that use the JDBC Thin Driver
- Writing a URL to Connect through a Firewall

Configuring a Firewall for Applets that use the JDBC Thin Driver

The instructions in this section assume that you are running an Oracle Net-compliant firewall.

Java applets do not have access to the local system—that is, they cannot get the hostname or environment variables locally—because of security limitations. As a result, the JDBC Thin driver cannot access the hostname on which it is running. The

firewall cannot be provided with the hostname. To allow requests from JDBC Thin clients to go through the firewall, you must do the following two things to the firewall's list of rules:

- Add the IP address (not the hostname) of the host on which the JDBC applet is running.
- Ensure that the hostname "__jdbc__" never appears in the firewall's rules. This hostname has been hard-coded as a false hostname inside the driver to force an IP address lookup. If you do enter this hostname in the list of rules, then every applet using Oracle's JDBC Thin driver will be able to go through your firewall.

By not including the Thin driver's hostname, the firewall is forced to do an IP address lookup and base its access decision on the IP address, instead of the hostname.

Writing a URL to Connect through a Firewall

To write a URL that allows you to connect through a firewall, you must specify the name of the firewall host and the name of the database host to which you want to connect.

For example, if you want to connect to a database on host `oraHost`, listening on port `1521`, with SID `ORCL`, and you are going though a firewall on host `fireWallHost`, listening on port `1610`, then use the following URL:

```
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:thin:" +
      "@(description=(address_list=" +
      (address=(protocol=tcp)(host=<firewall-host>)(port=1610))" +
      "(address=(protocol=tcp)(host=oraHost)(port=1521)))" +
      "(source_route=yes)" +
      "(connect_data=(INSTANCE_NAME=orcl)))");
);
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();
```

Note: To connect through a firewall, you cannot specify the URL in `host:port:sid` syntax. For example, a URL specified as follows will *not* work:

```
String connString =

"jdbc:oracle:thin:@example.us.oracle.com:1521:orcl
";

OracleDataSource ods = new OracleDataSource();
ods.setURL(connString);
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();
```

The first element in the `address_list` represents the connection to the firewall. The second element represents the database to which you want to connect. Note that the order in which you specify the addresses is important.

Notice that you can also write the preceding URL in this format:

```
String connString =
      "jdbc:oracle:thin:@(description=(address_list=
      (address=(protocol=tcp)(port=1600)(host=fireWallHost))
      (address=(protocol=tcp)(port=1521)(host=oraHost)))
      (connect_data=(INSTANCE_NAME=orcl))
      (source_route=yes))";
OracleDataSource ods = new OracleDataSource();
ods.setURL(connString);
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();
```

When your applet uses a URL similar to the one above, it will behave as if it were connected to the database on host `oraHost`.

> **Note:** All the parameters shown in the preceding example are required. In the `address_list`, the firewall address must precede the database server address.

For more information on the parameters used in the above example, see the *Oracle Net Services Administrator's Guide*. For more information on how to configure a firewall, please see your firewall's documentation or contact your firewall vendor.

Packaging Applets

After you have coded your applet, you must package it and make it available to users. To package an applet, you will need your applet class files and the JDBC driver class files contained in `classes12.jar`.

Follow these steps:

1. Move the JDBC driver classes file `classes12.jar` to an empty directory.

   If your applet will connect to a database with a non-`US7ASCII` and non-`WE8ISO8859P1` character set, then also move the `orai18n.jar` file to the same directory.

2. Add your applet classes files to the directory, and any other files the applet might require.

3. Zip the applet classes and driver classes together into a single ZIP or JAR file. The single zip file should contain the following:

   - class files from `classes12.jar` (and required class files from `orai18n.jar` if the applet requires Globalization Support)
   - your applet classes

   Additionally, if you are using `DatabaseMetaData` entry points in your applet, include the `oracle/jdbc/driver/OracleDatabaseMetaData.class` file. Note that this file is very large and might have a negative impact on performance. If you do not use `DatabaseMetaData` methods, omit this file.

4. Ensure that the ZIP or JAR file is *not* compressed.

You can now make the applet available to users. One way to do this is to add the `APPLET` tag to the HTML page from which the applet will be run. For example:

```
<APPLET WIDTH=500 HEIGHT=200 CODE=JdbcApplet ARCHIVE=JdbcApplet.zip
      CODEBASE=Applet_Samples
</APPLET>
```

You can find a description of the APPLET, CODE, ARCHIVE, CODEBASE, WIDTH, and HEIGHT parameters in the next section.

Specifying an Applet in an HTML Page

The APPLET tag specifies an applet that runs in the context of an HTML page. The APPLET tag can have these parameters: CODE, ARCHIVE, CODEBASE, WIDTH, and HEIGHT to specify the name of the applet and its location, and the height and width of the applet display area. These parameters are described in the following sections.

CODE, HEIGHT, and WIDTH

The HTML page that runs the applet must have an APPLET tag with an initial width and height to specify the size of the applet display area. You use the HEIGHT and WIDTH parameters to specify the size, measured in pixels. This size should not count any windows or dialogs that the applet opens.

The APPLET tag must also specify the name of the file that contains the applet's compiled Applet subclass—specify the file name with the CODE parameter. Any path must be relative to the base URL of the applet—the path cannot be absolute.

In the following example, JdbcApplet.class is the name of the applet's compiled applet subclass:

```
<APPLET CODE="JdbcApplet" WIDTH=500 HEIGHT=200>
</APPLET>
```

If you use this form of the CODE tag, then the classes for the applet and the classes for the JDBC Thin driver must be in the same directory as the HTML page.

Notice that in the CODE specification, you do not include the file name extension ".class".

CODEBASE

The CODEBASE parameter is optional and specifies the base URL of the applet; that is, the name of the directory that contains the applet's code. If it is not specified, then the document's URL is used. This means that the classes for the applet and the JDBC Thin driver must be in the same directory as the HTML page. For example, if the current directory is my_Dir:

```
<APPLET WIDTH=500 HEIGHT=200 CODE=JdbcApplet CODEBASE="."
</APPLET>
```

The entry CODEBASE="." indicates that the applet resides in the current directory (my_Dir). If the value of codebase was set to Applet_Samples, for example:

```
CODEBASE="Applet_Samples"
```

This would indicate that the applet resides in the my_Dir/Applet_Samples directory.

ARCHIVE

The ARCHIVE parameter is optional and specifies the name of the archive file (either a .zip or .jar file), if applicable, that contains the applet classes and resources the applet needs. Oracle recommends using a .zip file or .jar file, which saves many extra round-trips to the server.

The `.zip` (or `.jar`) file will be preloaded. If you have more than one archive in the list, separate them with commas. In the following example, the class files are stored in the archive file `JdbcApplet.zip`:

```
<APPLET CODE="JdbcApplet" ARCHIVE="JdbcApplet.zip" WIDTH=500 HEIGHT=200>
</APPLET>
```

Note: Version 3.0 browsers do not support the `ARCHIVE` parameter.

JDBC in the Server: the Server-Side Internal Driver

This section covers the following topics:

- Connecting to the Database with the Server-Side Internal Driver
- Exception-Handling Extensions for the Server-Side Internal Driver
- Session and Transaction Context for the Server-Side Internal Driver
- Testing JDBC on the Server
- Server-Side Character Set Conversion of oracle.sql.CHAR Data

This driver is intrinsically tied to the Oracle database and to the Java virtual machine (JVM). The driver runs as part of the same process as the database. It also runs within the default session—the same session in which the JVM was invoked.

The server-side internal driver is optimized to run within the database server and provide direct access to SQL data and PL/SQL subprograms on the local database. The entire JVM operates in the same address space as the database and the SQL engine. Access to the SQL engine is a function call; there is no network. This enhances the performance of your JDBC programs and is much faster than executing a remote Oracle Net call to access the SQL engine.

The server-side internal driver supports the same features, APIs, and Oracle extensions as the client-side drivers. This makes application partitioning very straightforward. For example, if you have a Java application that is data-intensive, you can easily move it into the database server for better performance, without having to modify the application-specific calls.

For general information about the Oracle Java platform server-side configuration or functionality, see the *Oracle Database Java Developer's Guide.*

Connecting to the Database with the Server-Side Internal Driver

As described in the preceding section, the server-side internal driver runs within a default session. You are already "connected". There are two methods you can use to access the default connection:

- Use the `OracleDataSource.getConnection()` method, with either `jdbc:oracle:kprb` or `jdbc:default:connection` as the URL string.
- Use the Oracle-specific `defaultConnection()` method of the `OracleDriver` class.

Using `defaultConnection()` is generally recommended.

Note: You are no longer required to register the `OracleDriver` class for connecting with the server-side internal driver.

Connecting with the OracleDriver Class defaultConnection() Method

The `oracle.jdbc.OracleDriver` class `defaultConnection()` method is an Oracle extension and always returns the same connection object. Even if you invoke this method multiple times, assigning the resulting connection object to different variable names, just a single connection object is reused.

You do not need to include a connect string in the `defaultConnection()` call. For example:

```
import java.sql.*;
import oracle.jdbc.*;

class JDBCConnection
{
  public static Connection connect() throws SQLException
  {
    Connection conn = null;
    try {
      // connect with the server-side internal driver
         OracleDriver ora = new OracleDriver();
         conn = ora.defaultConnection();
      }

    } catch (SQLException e) {...}
    return conn;
  }
}
```

Note that there is no `conn.close()` call in the example. When JDBC code is running inside the target server, the connection is an implicit data channel, not an explicit connection instance as from a client. It should typically not be closed.

If you do call the `close()` method, be aware of the following:

- All connection instances obtained through the `defaultConnection()` method, which actually all reference the same connection object, will be closed and unavailable for further use, with state and resource cleanup as appropriate. Executing `defaultConnection()` afterward would result in a new connection object.
- Even though the connection object is closed, the implicit connection to the database will not be closed.

Connecting with the OracleDataSource.getConnection() Method

To connect to the internal server connection from code that is running within the target server, you can use the `OracleDataSource.getConnection()` method with either of the following URLs:

```
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:kprb:");
Connection conn = ods.getConnection();
```

or:

```
OracleDataSource ods = new OracleDataSource();
```

```
ods.setURL("jdbc:default:connection:");
Connection conn = ods.getConnection();
```

Any user name or password you include in the URL is ignored in connecting to the server default connection.

The `OracleDataSource.getConnection()` method returns a new Java `Connection` object every time you call it. Note that although the method is not creating a new physical connection (only a single implicit connection is used), it is returning a new object.

The fact that `OracleDataSource.getConnection()` returns a new connection object every time you call it is significant if you are working with object maps (or "type maps"). A type map is associated with a specific `Connection` object and with any state that is part of the object. If you want to use multiple type maps as part of your program, then you can call `getConnection()` to create a new `Connection` object for each type map.

Exception-Handling Extensions for the Server-Side Internal Driver

The server-side internal driver, in addition to having standard exception-handling capabilities such as `getMessage()`, `getErrorCode()`, and `getSQLState()` (as described in "Processing SQL Exceptions" on page 4-25), offers extended features through the `oracle.jdbc.driver.OracleSQLException` class. This class is a subclass of the standard `java.sql.SQLException` class and is not available to the client-side JDBC drivers or the server-side Thin driver.

When an error condition occurs in the server, it often results in a series of related errors being placed in an internal error stack. The JDBC server-side internal driver retrieves errors from the stack and places them in a chain of `OracleSQLException` objects.

You can use the following methods in processing these exceptions:

- `SQLException getNextException()` (standard method)

  This method returns the next exception in the chain (or `null` if no further exceptions). You can start with the first exception you receive and work through the chain.

- `int getNumParameters()` (Oracle extension)

  Errors from the server usually include parameters, or variables, that are part of the error message. These may indicate what type of error occurred, what kind of operation was being attempted, or the invalid or affected values.

  This method returns the number of parameters included with this error.

- `Object[] getParameters()` (Oracle extension)

  This method returns a Java `Object[]` array containing the parameters included with this error.

Example

Following is an example of server-side error processing:

```
try
{
   // should get "ORA-942: table or view does not exist"
   stmt.execute("drop table no_such_table");
}
catch (OracleSQLException e)
{
```

```
    System.out.println(e.getMessage());
    // prints "ORA-942: table or view does not exist"

    System.out.println(e.getNumParameters());
    // prints "1"

    Object[] params = e.getParameters();
    System.out.println(params[0]);
    // prints "NO_SUCH_TABLE"
}
```

Session and Transaction Context for the Server-Side Internal Driver

The server-side driver operates within a default session and default transaction context. The default session is the session in which the JVM was invoked. In effect, you are already connected to the database on the server. This is different from the client side where there is no default session: you must explicitly connect to the database.

Auto-commit mode is disabled in the server. You must manage transaction `COMMIT` and `ROLLBACK` operations explicitly by using the appropriate methods on the connection object:

```
conn.commit();
```

or:

```
conn.rollback();
```

Testing JDBC on the Server

Almost any JDBC program that can run on a client can also run on the server. All the programs in the `samples` directory can be run on the server with only minor modifications. Usually, these modifications concern only the connection statement.

Consider the following code fragment which gets a connection to a database:

```
ods.setUrl(
"jdbc:oracle:oci:@(DESCRIPTION=
  (ADDRESS=(PROTOCOL=TCP)(HOST=cluster_alias)
    (PORT=1521))
    (CONNECT_DATA=(SERVICE_NAME=service_name)))");
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();
```

We can modify this code fragment for use in the server-side internal driver. In the server-side internal driver, no user, password, or database information is necessary. For the connection statement, you simply use:

```
ods.setUrl(
"jdbc:oracle:kprb:@");
Connection conn = ods.getConnection();
```

However, the most convenient way to get a connection is to call the static `OracleDriver.defaultConnection()` method, as shown below:

```
Connection conn = OracleDriver.defaultConnection();
```

Loading an Application into the Server

When loading an application into the server, you can load `.class` files that you have already compiled on the client, or you can load `.java` source files and have them compiled automatically in the server.

In either case, use the Oracle `loadjava` client-side utility to load your files. You can either specify source file names on the command line (note that the command line understands wildcards), or put the files into a JAR file and specify the JAR file name on the command line. The `loadjava` utility is discussed in detail in the *Oracle Database Java Developer's Guide.*

The `loadjava` script, which runs the actual utility, is in the `bin` subdirectory under your `[Oracle Home]` directory. This directory should already be in your path once Oracle has been installed.

> **Note:** The `loadjava` utility supports compressed files.

Loading Class Files into the Server

Consider a case where you have three class files in your application: `Foo1.class`, `Foo2.class`, and `Foo3.class`. The following three examples demonstrate: 1) specifying the individual class file names; 2) specifying the class file names using a wildcard; and 3) specifying a JAR file that contains the class files.

Each class is written into its own class schema object in the server.

These three examples use the default OCI driver in loading the files:

```
loadjava -user scott/tiger Foo1.class Foo2.class Foo3.class
```

or:

```
loadjava -user scott/tiger Foo*.class
```

or:

```
loadjava -user scott/tiger Foo.jar
```

Or use the following command to load with the Thin driver (specifying the `-thin` option and an appropriate URL):

```
loadjava -thin -user scott/tiger@localhost:1521:ORCL Foo.jar
```

(Whether to use an OCI driver or the Thin driver to load classes depends on your particular environment and which performs better for you.)

> **Note:** Because the server-side embedded JVM uses JDK 1.2.x, it is advisable to compile classes under JDK 1.2.x if they will be loaded into the server. This will catch incompatibilities during compilation, instead of at runtime (for example, JDK 1.1.x artifacts such as leftover use of the `oracle.jdbc2` package).

Loading Source Files into the Server

If you enable the `loadjava -resolve` option in loading a `.java` source file, then the server-side compiler will compile your application as it is loaded, resulting in both a source schema object for the original source code, and one or more class schema objects for the compiled output.

If you do not specify `-resolve`, then the source is loaded into a source schema object without any compilation. In this case, however, the source *is* implicitly compiled the first time an attempt is made to use a class defined in the source.

For example, run `loadjava` as follows to load and compile `Foo.java`, using the default OCI driver:

```
loadjava -user scott/tiger -resolve Foo.java
```

Or use the following command to load with the Thin driver (specifying the `-thin` option and an appropriate URL):

```
loadjava -thin -user scott/tiger@localhost:1521:ORCL -resolve Foo.java
```

Either of these will result in appropriate class schema objects being created in addition to the source schema object.

Note: Oracle generally recommends compiling source on the client whenever possible, and loading the `.class` files instead of the source files into the server.

Server-Side Character Set Conversion of oracle.sql.CHAR Data

The server-side internal driver performs character set conversions for `oracle.sql.CHAR` in C. This is a different implementation than for the client-side drivers, which perform character set conversions for `oracle.sql.CHAR` in Java, and offers better performance. For more information on the `oracle.sql.CHAR` class, see "Class oracle.sql.CHAR" on page 10-21.

24

Reference Information

This chapter contains detailed JDBC reference information, including the following topics:

- Valid SQL-JDBC Datatype Mappings
- Supported SQL and PL/SQL Datatypes
- Embedded SQL92 Syntax
- Oracle JDBC Notes and Limitations

Valid SQL-JDBC Datatype Mappings

Table 4–3 in Chapter 4 describes the default mappings between Java classes and SQL datatypes supported by the Oracle JDBC drivers. Compare the contents of the **JDBC Datatypes**, **Standard Java Types**, and **SQL Datatypes** columns in Table 4–3 with the contents of Table 24–1 below.

Table 24–1 lists all the possible Java types to which a given SQL datatype can be validly mapped. The Oracle JDBC drivers will support these "non-default" mappings. For example, to materialize SQL `CHAR` data in an `oracle.sql.CHAR` object use the `getCHAR()` method. To materialize it as a `java.math.BigDecimal` object, use the `getBigDecimal()` method.

Notes: For classes where `oracle.sql.ORAData` appears in italic, these can be generated by JPublisher.

Table 24–1 Valid SQL Datatype-Java Class Mappings

These SQL datatypes:	Can be materialized as these Java types:
`CHAR, VARCHAR2, LONG`	`oracle.sql.CHAR`
	`java.lang.String`
	`java.sql.Date`
	`java.sql.Time`
	`java.sql.Timestamp`
	`java.lang.Byte`
	`java.lang.Short`
	`java.lang.Integer`

Table 24–1 (Cont.) Valid SQL Datatype-Java Class Mappings

These SQL datatypes:	Can be materialized as these Java types:
	java.lang.Long
	java.lang.Float
	java.lang.Double
	java.math.BigDecimal
	byte, short, int, long, float, double
DATE	oracle.sql.DATE
	java.sql.Date
	java.sql.Time
	java.sql.Timestamp
	java.lang.String
NUMBER	oracle.sql.NUMBER
	java.lang.Byte
	java.lang.Short
	java.lang.Integer
	java.lang.Long
	java.lang.Float
	java.lang.Double
	java.math.BigDecimal
	byte, short, int, long, float, double
OPAQUE	oracle.sql.OPAQUE
RAW, LONG RAW	oracle.sql.RAW
	byte[]
ROWID	oracle.sql.CHAR
	oracle.sql.ROWID
	java.lang.String
BFILE	oracle.sql.BFILE
BLOB	oracle.sql.BLOB
	java.sql.Blob
CLOB	oracle.sql.CLOB
	java.sql.Clob
TIMESTAMP	java.sql.Date, oracle.sql.DATE, java.sql.Time, java.sql.Timestamp, oracle.sql.TIMESTAMP, java.lang.String, byte[]

Table 24–1 (Cont.) Valid SQL Datatype-Java Class Mappings

These SQL datatypes:	Can be materialized as these Java types:
`TIMESTAMP WITH TIME ZONE`	`java.sql.Date, oracle.sql.DATE, java.sql.Time, java.sql.Timestamp, oracle.sql.TIMESTAMPTZ, java.lang.String, byte[]`
`TIMESTAMP WITH LOCAL TIME ZONE`	`java.sql.Date, oracle.sql.DATE, java.sql.Time, java.sql.Timestamp, oracle.sql.TIMESTAMPLTZ, java.lang.String, byte[]`

Object types	`oracle.sql.STRUCT`
	`java.sql.Struct`
	`java.sql.SqlData`
	`oracle.sql.ORAData`

Reference types	`oracle.sql.REF`
	`java.sql.Ref`
	`oracle.sql.ORAData`

Nested table types and `VARRAY` types	`oracle.sql.ARRAY`
	`java.sql.Array`
	`oracle.sql.ORAData`

Notes:

- The type `UROWID` is not supported.
- The `oracle.sql.Datum` class is abstract. The value passed to a parameter of type `oracle.sql.Datum` must be of the Java type corresponding to the underlying SQL type. Likewise, the value returned by a method with return type `oracle.sql.Datum` must be of the Java type corresponding to the underlying SQL type.
- The mappings to `oracle.sql` classes are optimal if no conversion from SQL format to Java format is necessary.

Supported SQL and PL/SQL Datatypes

The tables in this section list SQL and PL/SQL datatypes, and whether the Oracle JDBC drivers support them. Table 24–2 describes Oracle JDBC driver support for SQL datatypes.

Table 24–2 Support for SQL Datatypes

SQL Datatype	Supported by JDBC Drivers?
BFILE	yes
BLOB	yes
CHAR	yes
CLOB	yes
DATE	yes
NCHAR	no (see Note)
NCHAR VARYING	no
NUMBER	yes
NVARCHAR2	no (see Note)
RAW	yes
REF	yes
ROWID	yes
UROWID	no
VARCHAR2	yes

Note: The types `NCHAR` and `NVARCHAR2` are supported indirectly. There is no corresponding `java.sql.Types` type (use `CHAR`), but if your application invokes `formOfUse(NCHAR)` then these types can be accessed. See "NCHAR, NVARCHAR2, NCLOB and the defaultNChar Property" on page 12-2 for details.

Table 24–3 describes Oracle JDBC support for the ANSI-supported SQL datatypes.

Table 24–3 Support for ANSI-92 SQL Datatypes

ANSI-Supported SQL Datatype	Supported by JDBC Drivers?
CHARACTER	yes
DEC	yes
DECIMAL	yes
DOUBLE PRECISION	yes
FLOAT	yes
INT	yes
INTEGER	yes
NATIONAL CHARACTER	no
NATIONAL CHARACTER VARYING	no

Table 24–3 (Cont.) Support for ANSI-92 SQL Datatypes

ANSI-Supported SQL Datatype	Supported by JDBC Drivers?
NATIONAL CHAR	yes
NATIONAL CHAR VARYING	no
NCHAR	yes
NCHAR VARYING	no
NUMERIC	yes
REAL	yes
SMALLINT	yes
VARCHAR	yes

Table 24–4 describes Oracle JDBC driver support for SQL User-Defined types.

Table 24–4 Support for SQL User-Defined Types

SQL User-Defined type	Supported by JDBC Drivers?
OPAQUE	yes
Reference types	yes
Object types (`JAVA_OBJECT`)	yes
Nested table types and VARRAY types	yes

Table 24–5 describes Oracle JDBC driver support for PL/SQL datatypes. Note that PL/SQL datatypes include these categories:

- scalar types
- scalar character types (includes boolean and date datatypes)
- composite types
- reference types
- LOB types

Table 24–5 Support for PL/SQL Datatypes

PL/SQL Datatype	Supported by JDBC Drivers?
Scalar Types:	
BINARY INTEGER	yes
DEC	yes
DECIMAL	yes
DOUBLE PRECISION	yes
FLOAT	yes
INT	yes
INTEGER	yes
NATURAL	yes
NATURAL*n*	no

Table 24–5 (Cont.) Support for PL/SQL Datatypes

PL/SQL Datatype	Supported by JDBC Drivers?
NUMBER	yes
NUMERIC	yes
PLS_INTEGER	yes
POSITIVE	yes
POSITIVE*n*	no
REAL	yes
SIGNTYPE	yes
SMALLINT	yes
Scalar Character Types:	
CHAR	yes
CHARACTER	yes
LONG	yes
LONG RAW	yes
NCHAR	no (see Note)
NVARCHAR2	no (see Note)
RAW	yes
ROWID	yes
STRING	yes
UROWID	no
VARCHAR	yes
VARCHAR2	yes
BOOLEAN	yes
DATE	yes
Composite Types:	
RECORD	no
TABLE	no
VARRAY	yes
Reference Types:	
REF CURSOR types	yes
object reference types	yes
LOB Types:	
BFILE	yes
BLOB	yes
CLOB	yes
NCLOB	yes

Notes:

- The types NATURAL, NATURAL*n*, POSITIVE, POSITIVE*n*, and SIGNTYPE are subtypes of BINARY INTEGER.
- The types DEC, DECIMAL, DOUBLE PRECISION, FLOAT, INT, INTEGER, NUMERIC, REAL, and SMALLINT are subtypes of NUMBER.
- The types NCHAR and NVARCHAR2 are supported indirectly. There is no corresponding java.sql.Types type (use CHAR), but if your application invokes formOfUse(NCHAR) then these types can be accessed. See "NCHAR, NVARCHAR2, NCLOB and the defaultNChar Property" on page 12-2 for details.

Embedded SQL92 Syntax

Oracle's JDBC drivers support some embedded SQL92 syntax. This is the syntax that you specify between curly braces. The current support is basic. This section describes the support offered by the drivers for the following SQL92 constructs:

- Time and Date Literals
- Scalar Functions
- LIKE Escape Characters
- Outer Joins
- Function Call Syntax

Where driver support is limited, these sections also describe possible workarounds.

Disabling Escape Processing

Escape processing for SQL92 syntax is enabled by default, which results in the JDBC driver performing escape substitution before sending the SQL code to the database. If you want the driver to use regular Oracle SQL syntax, which is more efficient than SQL92 syntax and escape processing, then use this statement:

```
stmt.setEscapeProcessing(false);
```

Note: Call PreparedStatement.setEscapeProcessing() immediately after creating a statement. If you call this method after the SQL text has already been processed for escapes, a SQLException will be thrown.

Time and Date Literals

Databases differ in the syntax they use for date, time, and timestamp literals. JDBC supports dates and times written only in a specific format. This section describes the formats you must use for date, time, and timestamp literals in SQL statements.

Date Literals

The JDBC drivers support date literals in SQL statements written in the format:

```
{d 'yyyy-mm-dd'}
```

Where `yyyy-mm-dd` represents the year, month, and day—for example:

```
{d '1995-10-22'}
```

The JDBC drivers will replace this escape clause with the equivalent Oracle representation: "22 OCT 1995".

This code snippet contains an example of using a date literal in a SQL statement.

```
// Connect to the database
// You can put a database name after the @ sign in the connection URL.
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:oci:@");
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();

// Create a Statement
Statement stmt = conn.createStatement ();

// Select the ename column from the emp table where the hiredate is Jan-23-1982
ResultSet rset = stmt.executeQuery
                 ("SELECT ename FROM emp WHERE hiredate = {d '1982-01-23'}");

// Iterate through the result and print the employee names
while (rset.next ())
   System.out.println (rset.getString (1));
```

Time Literals

The JDBC drivers support time literals in SQL statements written in the format:

```
{t 'hh:mm:ss'}
```

where `hh:mm:ss` represents the hours, minutes, and seconds—for example:

```
{t '05:10:45'}
```

The JDBC drivers will replace this escape clause with the equivalent Oracle representation: "05:10:45".

If the time is specified as:

```
{t '14:20:50'}
```

Then the equivalent Oracle representation would be "14:20:50", assuming the server is using a 24-hour clock.

This code snippet contains an example of using a time literal in a SQL statement.

```
ResultSet rset = stmt.executeQuery
```

```
                ("SELECT ename FROM emp WHERE hiredate = {t '12:00:00'}");
```

Timestamp Literals

The JDBC drivers support timestamp literals in SQL statements written in the format:

```
{ts 'yyyy-mm-dd hh:mm:ss.f...'}
```

where `yyyy-mm-dd hh:mm:ss.f...` represents the year, month, day, hours, minutes, and seconds. The fractional seconds portion (`.f...`) is optional and can be omitted. For example: `{ts '1997-11-01 13:22:45'}` represents, in Oracle format, NOV 01 1997 13:22:45.

This code snippet contains an example of using a timestamp literal in a SQL statement.

```
ResultSet rset = stmt.executeQuery
    ("SELECT ename FROM emp WHERE hiredate = {ts '1982-01-23 12:00:00'}");
```

Scalar Functions

The Oracle JDBC drivers do not support all scalar functions. To find out which functions the drivers support, use the following methods supported by the Oracle-specific `oracle.jdbc.OracleDatabaseMetaData` class and the standard Java `java.sql.DatabaseMetadata` interface:

- `getNumericFunctions()`: Returns a comma-separated list of math functions supported by the driver. For example, `ABS`, `COS`, `SQRT`.
- `getStringFunctions()`: Returns a comma-separated list of string functions supported by the driver. For example, `ASCII`, `LOCATE`.
- `getSystemFunctions()`: Returns a comma-separated list of system functions supported by the driver. For example, `DATABASE`, `USER`.
- `getTimeDateFunctions()`: Returns a comma-separated list of time and date functions supported by the driver. For example, `CURDATE`, `DAYOFYEAR`, `HOUR`.

> **Note:** Oracle's JDBC drivers support `fn`, the function keyword.

LIKE Escape Characters

The characters "`%`" and "`_`" have special meaning in SQL `LIKE` clauses (you use "`%`" to match zero or more characters, "`_`" to match exactly one character). If you want to interpret these characters literally in strings, you precede them with a special escape character. For example, if you want to use the ampersand "`&`" as the escape character, you identify it in the SQL statement as {escape '`&`'}:

```
Statement stmt = conn.createStatement ();

// Select the empno column from the emp table where the ename starts with '_'
ResultSet rset = stmt.executeQuery
          ("SELECT empno FROM emp WHERE ename LIKE '&_%' {ESCAPE '&'}");

// Iterate through the result and print the employee numbers
while (rset.next ())
   System.out.println (rset.getString (1));
```

Note: If you want to use the backslash character (\) as an escape character, you must enter it twice (that is, \\). For example:

```
ResultSet rset = stmt.executeQuery("SELECT empno
FROM emp
                WHERE ename LIKE '\\_%' {escape
'\\'}");
```

Outer Joins

Oracle's JDBC drivers do not support outer join syntax: {*oj outer-join*}. The workaround is to use Oracle outer join syntax:

Instead of:

```
Statement stmt = conn.createStatement ();
ResultSet rset = stmt.executeQuery
     ("SELECT ename, dname
       FROM {OJ dept LEFT OUTER JOIN emp ON dept.deptno = emp.deptno}
       ORDER BY ename");
```

Use Oracle SQL syntax:

```
Statement stmt = conn.createStatement ();
ResultSet rset = stmt.executeQuery
     ("SELECT ename, dname
       FROM emp a, dept b WHERE a.deptno = b.deptno(+)
       ORDER BY ename");
```

Function Call Syntax

Oracle's JDBC drivers support the following procedure and function call syntax:

Procedure calls (without a return value):

```
{ call procedure_name (argument1, argument2,...) }
```

Function calls (with a return value):

```
{ ? = call procedure_name (argument1, argument2,...) }
```

SQL92 to SQL Syntax Example

You can write a simple program to translate SQL92 syntax to standard SQL syntax. The following program prints the comparable SQL syntax for SQL92 statements for function calls, date literals, time literals, and timestamp literals. In the program, the `oracle.jdbc.OracleSql` class `parse()` method performs the conversions.

```
import oracle.jdbc.OracleSql;

public class Foo
{
   public static void main (String args[]) throws Exception
   {
      show ("{call foo(?, ?)}");
      show ("{? = call bar (?, ?)}");
      show ("{d '1998-10-22'}");
      show ("{t '16:22:34'}");
      show ("{ts '1998-10-22 16:22:34'}");
```

```
   }

   public static void show (String s) throws Exception
   {
      System.out.println (s + " => " +
         oracle.jdbc.OracleDriver.processSqlEscapes(s));
   }
}
```

The following code is the output that prints the comparable SQL syntax.

```
{call foo(?, ?)} => BEGIN foo(:1, :2); END;
{? = call bar (?, ?)} => BEGIN :1 := bar (:2, :3); END;
{d '1998-10-22'} => TO_DATE ('1998-10-22', 'YYYY-MM-DD')
{t '16:22:34'} => TO_DATE ('16:22:34', 'HH24:MI:SS')
{ts '1998-10-22 16:22:34'} => TO_DATE ('1998-10-22 16:22:34', 'YYYY-MM-DD
HH24:MI:SS')
```

Oracle JDBC Notes and Limitations

The following limitations exist in the Oracle JDBC implementation, but all of them are either insignificant or have easy workarounds.

CursorName

Oracle JDBC drivers do not support the `get getCursorName()` and `setCursorName()` methods, because there is no convenient way to map them to Oracle constructs. Oracle recommends using `ROWID` instead. For more information on how to use and manipulate `ROWID`s, see "Oracle ROWID Type" on page 10-23.

SQL92 Outer Join Escapes

Oracle JDBC drivers do not support SQL92 outer join escapes. Use Oracle SQL syntax with "(+)" instead. For more information on SQL92 syntax, see "Embedded SQL92 Syntax" on page 24-7.

PL/SQL TABLE, BOOLEAN, and RECORD Types

It is not feasible for Oracle JDBC drivers to support calling arguments or return values of the PL/SQL `RECORD`, `BOOLEAN`, or table with non-scalar element types. However, Oracle JDBC drivers support PL/SQL index-by table of scalar element types. For a complete description of this, see "Accessing PL/SQL Index-by Tables" on page 19-10.

As a workaround to PL/SQL `RECORD`, `BOOLEAN`, or non-scalar table types, create wrapper procedures that handle the data as types supported by JDBC. For example, to wrap a stored procedure that uses PL/SQL booleans, create a stored procedure that takes a character or number from JDBC and passes it to the original procedure as `BOOLEAN` or, for an output parameter, accepts a `BOOLEAN` argument from the original procedure and passes it as a `CHAR` or `NUMBER` to JDBC. Similarly, to wrap a stored procedure that uses PL/SQL records, create a stored procedure that handles a record in its individual components (such as `CHAR` and `NUMBER`) or in a structured object type. To wrap a stored procedure that uses PL/SQL tables, break the data into components or perhaps use Oracle collection types.

For an example of a workaround for `BOOLEAN`, see "Boolean Parameters in PL/SQL Stored Procedures" on page 26-7.

IEEE 754 Floating Point Compliance

The arithmetic for the Oracle `NUMBER` type does not comply with the IEEE 754 standard for floating-point arithmetic. Therefore, there can be small disagreements between the results of computations performed by Oracle and the same computations performed by Java.

Oracle stores numbers in a format compatible with decimal arithmetic and guarantees 38 decimal digits of precision. It represents zero, minus infinity, and plus infinity exactly. For each positive number it represents, it represents a negative number of the same absolute value.

It represents every positive number between 10^{-30} and $(1 - 10^{-38}) * 10^{126}$ to full 38-digit precision.

Catalog Arguments to DatabaseMetaData Calls

Certain `DatabaseMetaData` methods define a `catalog` parameter. This parameter is one of the selection criteria for the method. Oracle does not have multiple catalogs, but it does have packages. For more information on how the Oracle JDBC drivers treat the `catalog` argument, see "DatabaseMetaData TABLE_REMARKS Reporting" on page 22-20.

SQLWarning Class

The `java.sql.SQLWarning` class provides information on a database access warning. Warnings typically contain a description of the warning and a code that identifies the warning. Warnings are silently chained to the object whose method caused it to be reported. The Oracle JDBC drivers generally do not support `SQLWarning`. (As an exception to this, scrollable result set operations do generate SQL warnings, but the `SQLWarning` instance is created on the client, not in the database.)

For information on how the Oracle JDBC drivers handle errors, see "Processing SQL Exceptions" on page 4-25.

Binding Named Parameters

Binding by name is not supported when using the `setXXX` methods. Under certain circumstances, previous versions of the Oracle JDBC drivers have allowed binding statement variables by name when using the `setXXX` methods. In the following statement, the named variable `EmpId` would be bound to the integer `314159`.

```
PreparedStatement p = conn.prepareStatement
  ("SELECT name FROM emp WHERE id = :EmpId");
  p.setInt(1, 314159);
```

This capability to bind by name using the `setXXX` methods is not part of the JDBC specification, and Oracle does not support it. The JDBC drivers can throw a `SQLException` or produce unexpected results. In 10*g* Release 1 (10.1) JDBC drivers, bind by name is supported using the `setXXXAtName` methods. See "Interface oracle.jdbc.OracleCallableStatement" on page 10-15 and "Interface oracle.jdbc.OraclePreparedStatement" on page 10-14.

Retaining Bound Values

Before Oracle9*i*, the Oracle JDBC drivers did not retain bound values from one call of execute to the next as specified in JDBC 1.0. All releases after Oracle9*i* have retained bound values. For example:

```
PreparedStatement p = conn.prepareStatement
    ("SELECT name FROM emp WHERE id = ? AND dept = ?");
p.setInt(1, 314159);
p.setString(2, "SALES");
ResultSet r1 = p.execute();
p.setInt(1, 425260);
ResultSet r2 = p.execute();
```

Previously, a `SQLException` would be thrown by the second `execute()` call because no value was bound to the second argument. In this release, the second execute will return the correct value, retaining the binding of the second argument to the string "`SALES`".

If the retained bound value is a stream, then the Oracle JDBC drivers will not reset the stream. Unless the application code resets, repositions, or otherwise modifies the stream, the subsequent execute calls will send `NULL` as the value of the argument.

25

Proxy Authentication

This chapter contains the following sections:

Middle-Tier Authentication Through Proxy Connections

Middle-tier authentication allows one JDBC connection (session) to act as a proxy for other JDBC connections. An application may need proxy authentication for any of the following reasons:

- The middle tier does not know the password of the proxy user. It is sometimes a security concern for the middle tier to know the passwords of all the database users.

  This is done by first authenticating using:

  ```
  alter user jeff grant connect through scott with roles role1, role2;
  ```

  Having authenticated, your application can connect as "`jeff`" using the already authenticated credentials of "`scott`". Although the created session will behave as if "`jeff`" was connected normally (using "`jeff`"/"`jeff-password`"), "`jeff`" will not have to divulge its password to the middle tier. The proxy section has access to the schema of "`jeff`" as well as to what is indicated in the list of roles. Therefore, if "`scott`" wants "`jeff`" to access its table `EMP`, the following code can be used:

  ```
  create role role1;
  grant select on EMP to role1;
  ```

  The role clause can also be thought as limiting "`jeff`'s" access to only those database objects of "`scott`" mentioned in the list of the roles. The list of roles can be empty.

- Accounting purposes. The transactions made via proxy sessions can be better accounted by proxying the user ("`jeff`"), under different users such as "`scott`", "`scott2`" assuming "`scott`" and "`scott2`" are authenticated. Transactions made under these different proxy sessions by "`jeff`" can be logged separately.

There are three ways to create proxy sessions in the OCI driver. Roles can be associated with any of the following options:

- `USER NAME`: This is done by supplying the user name and/or the password. The reason why the "password" option exists is so that database operations made by the user ("`jeff`"), can be accounted. The SQL clause is:

  ```
  alter user jeff grant connect through scott authenticated using password;
  ```

  Having no authenticated clause implies the default—authenticated using the user-name without the password requirement.

- `DISTINGUISHED NAME`: This is a global name in lieu of the password of the user being proxied for. So you could say "create user jeff identified globally as:

  ```
  'CN=jeff,OU=americas,O=oracle,L=redwoodshores,ST=ca,C=us';
  ```

  The string after the "globally as" clause is the distinguished name. It is then necessary to authenticate as:

  ```
  alter user jeff grant connect through scott authenticated using distinguished
  name;
  ```

- `CERTIFICATE`: This is a more encrypted way of passing the credentials of the user (to be proxied) to the database. The certificate contains the distinguished encoded name. One way of generating it is by creating a wallet (using "`runutl mkwallet`"), then decoding the wallet to get the certificate. It is then necessary to authenticate as:

  ```
  alter user jeff grant connect through scott authenticated using certificate;
  ```

The following code shows signatures of the `getProxyConnection()` method with information about the proxy type process:

```
/*
   * For creating a proxy connection. All macros are defined
   * in OracleOCIConnectionPool.java
   *
   * @param proxyType  Can be one of following types
              PROXYTYPE_USER_NAME
                       - This will be the normal mode of specifying the user
                         name in proxyUser as in Oracle8i

              PROXYTYPE_DISTINGUISHED_NAME
                       - This will specify the distinguished name of the user
                         in proxyUser

             PROXYTYPE_CERTIFICATE
                       - This will specify the proxy certificate

     The Properties (ie prop) should be set as follows.

     If PROXYTYPE_USER_NAME
        PROXY_USER_NAME and/or PROXY_USER_PASSWORD depending
           on how the connection-pool owner was authenticated
           to act as proxy for this proxy user
           PROXY_USER_NAME (String) = user to be proxied for
           PROXY_PASSWORD (String) = password of the user to be proxied for

    else if PROXYTYPE_DISTINGUISHED_NAME
         PROXY_DISTINGUISHED_NAME (String) = (global) distinguished name of the
user to be proxied for
```

```
    else if PROXYTYPE_CERTIFICATE (byte[])
         PROXY_CERTIFICATE = certficate containing the encoded
                                distinguished name



    PROXY_ROLES (String[])  Set of roles which this proxy connection can use.
Roles can be null, and can be associated
with any of the above proxy methods.

   *
   * @return   connection object
   *
   * Notes: The user and password used to create OracleOCIConnectionPool()
   *        must be allowed to act as proxy for user 'us'.
   */
   public synchronized OracleConnection getProxyConnection(String proxyType,
     Properties prop)
     throws SQLException
```

26

Coding Tips and Troubleshooting

This chapter describes how to optimize and troubleshoot a JDBC application or applet, including the following topics:

- JDBC and Multithreading
- Performance Optimization
- Common Problems
- Basic Debugging Procedures
- Transaction Isolation Levels and Access Modes

JDBC and Multithreading

The Oracle JDBC drivers provide full support for programs that use Java multithreading. The following example creates a specified number of threads and lets you determine whether or not the threads will share a connection. If you choose to share the connection, then the same JDBC connection object will be used by all threads (each thread will have its own statement object, however).

Because all Oracle JDBC API methods are synchronized, if two threads try to use the connection object simultaneously, then one will be forced to wait until the other one finishes its use.

The program displays each thread ID and the employee name and employee ID associated with that thread.

Execute the program by entering:

```
java JdbcMTSample [number_of_threads] [share]
```

Where *number_of_threads* is the number of threads that you want to create, and `share` specifies that you want the threads to share the connection. If you do not specify the number of threads, then the program creates 10 by default.

```
/*
 * This sample is a  multi-threaded JDBC program.
 */

import java.sql.*;
import oracle.jdbc.OracleStatement;

public class JdbcMTSample extends Thread
{
  // Default no of threads to 10
  private static int NUM_OF_THREADS = 10;
```

```
int m_myId;

static  int c_nextId = 1;
static  Connection s_conn = null;
static  boolean   share_connection = false;

synchronized static int getNextId()
{
    return c_nextId++;
}

public static void main (String args [])
{
  try
  {

    // If NoOfThreads is specified, then read it
    if ((args.length > 2)  ||
         ((args.length > 1) && !(args[1].equals("share"))))
    {
       System.out.println("Error: Invalid Syntax. ");
       System.out.println("java JdbcMTSample [NoOfThreads] [share]");
       System.exit(0);
    }

    if (args.length > 1)
    {
       share_connection = true;
       System.out.println
              ("All threads will be sharing the same connection");
    }

    // get the no of threads if given
    if (args.length > 0)
       NUM_OF_THREADS = Integer.parseInt (args[0]);

    // get a shared connection
    if (share_connection)
        {
        OracleDataSource ods = new OracleDataSource();
        ods.setURL("jdbc:oracle:" +args[1]);
        ods.setUser("scott");
        ods.setPassword("tiger");
        Connection s_conn = ods.getConnection();
        }
    // Create the threads
    Thread[] threadList = new Thread[NUM_OF_THREADS];

    // spawn threads
    for (int i = 0; i < NUM_OF_THREADS; i++)
    {
        threadList[i] = new JdbcMTSample();
        threadList[i].start();
    }

    // Start everyone at the same time
    setGreenLight ();

    // wait for all threads to end
```

```
    for (int i = 0; i < NUM_OF_THREADS; i++)
    {
        threadList[i].join();
    }

    if (share_connection)
    {
        s_conn.close();
        s_conn = null;
    }

  }
  catch (Exception e)
  {
     e.printStackTrace();
  }

}

public JdbcMTSample()
{
   super();
   // Assign an Id to the thread
   m_myId = getNextId();
}

public void run()
{
  Connection conn = null;
  ResultSet     rs   = null;
  Statement  stmt = null;

  try
  {
    // Get the connection

    if (share_connection)
      stmt = s_conn.createStatement (); // Create a Statement
    else
    {
      OracleDataSource ods = new OracleDataSource();
      ods.setURL("jdbc:oracle:oci:@");
      ods.setUser("scott");
      ods.setPassword("tiger");
      Connection conn = ods.getConnection();
      stmt = conn.createStatement (); // Create a Statement
    }

    while (!getGreenLight())
      yield();

    // Execute the Query
    rs = stmt.executeQuery ("select * from EMP");

    // Loop through the results
    while (rs.next())
    {
      System.out.println("Thread " + m_myId +
                         " Employee Id : " + rs.getInt(1) +
                         " Name : " + rs.getString(2));
```

```
          yield();  // Yield To other threads
        }

        // Close all the resources
        rs.close();
        rs = null;

        // Close the statement
        stmt.close();
        stmt = null;

        // Close the local connection
        if ((!share_connection) && (conn != null))
        {
           conn.close();
           conn = null;
        }
        System.out.println("Thread " + m_myId +  " is finished. ");
      }
      catch (Exception e)
      {
        System.out.println("Thread " + m_myId + " got Exception: " + e);
        e.printStackTrace();
        return;
      }
    }

    static boolean greenLight = false;
    static synchronized void setGreenLight () { greenLight = true; }
    synchronized boolean getGreenLight () { return greenLight; }

}
```

Performance Optimization

You can significantly enhance the performance of your JDBC programs by using any of these features:

- Disabling Auto-Commit Mode
- Standard Fetch Size and Oracle Row Prefetching
- Standard and Oracle Update Batching

Disabling Auto-Commit Mode

Auto-commit mode indicates to the database whether to issue an automatic `COMMIT` operation after every SQL operation. Being in auto-commit mode can be expensive in terms of time and processing effort if, for example, you are repeating the same statement with different bind variables.

By default, new connection objects are in auto-commit mode. However, you can disable auto-commit mode with the `setAutoCommit()` method of the connection object (either `java.sql.Conection` or `oracle.jdbc.OracleConnection`).

In auto-commit mode, the `COMMIT` operation occurs either when the statement completes or the next execute occurs, whichever comes first. In the case of statements returning a `ResultSet`, the statement completes when the last row of the `ResultSet` has been retrieved or when the `ResultSet` has been closed. In more complex cases, a

single statement can return multiple results as well as output parameter values. Here, the `COMMIT` occurs when all results and output parameter values have been retrieved.

If you disable auto-commit mode with a `setAutoCommit(false)` call, then you must manually commit or roll back groups of operations using the `commit()` or `rollback()` method of the connection object.

Example: Disabling AutoCommit

The following example illustrates loading the driver and connecting to the database. Because new connections are in auto-commit mode by default, this example shows how to disable auto-commit. In the example, `conn` represents the `Connection` object, and `stmt` represents the `Statement` object.

```
// Connect to the database
// You can put a database hostname after the @ sign in the connection URL.
   OracleDataSource ods = new OracleDataSource();
   ods.setURL("jdbc:oracle:oci:@");
   ods.setUser("scott");
   ods.setPassword("tiger");
   Connection conn = ods.getConnection();

// It's faster when auto commit is off
conn.setAutoCommit (false);

// Create a Statement
Statement stmt = conn.createStatement ();
...
```

Standard Fetch Size and Oracle Row Prefetching

Oracle JDBC connection and statement objects allow you to specify the number of rows to prefetch into the client with each trip to the database while a result set is being populated during a query. You can set a value in a connection object that affects each statement produced through that connection, and you can override that value in any particular statement object. The default value in a connection object is 10. Prefetching data into the client reduces the number of round trips to the server.

Similarly, and with more flexibility, JDBC 2.0 allows you to specify the number of rows to fetch with each trip, both for statement objects (affecting subsequent queries) and for result set objects (affecting row refetches). By default, a result set uses the value for the statement object that produced it. If you do not set the JDBC 2.0 fetch size, then the Oracle connection row-prefetch value is used by default.

For more information, see "Oracle Row Prefetching" on page 22-15 and "Fetch Size" on page 17-15.

Standard and Oracle Update Batching

The Oracle JDBC drivers allow you to accumulate `INSERT`, `DELETE`, and `UPDATE` operations of prepared statements at the client and send them to the server in batches. This feature reduces round trips to the server. You can either use Oracle update batching, which typically executes a batch implicitly once a pre-set batch value is reached, or standard update batching, where the batch is executed explicitly.

For a description of the update batching models and how to use them, see "Update Batching" on page 22-1.

Mapping Between Built-in SQL and Java Types

The SQL "built-in" types are those types with system-defined names such as `NUMBER`, `CHAR`, etc. (as opposed to the Oracle objects, varray, and nested table types, which have user-defined names). In JDBC programs that access data of built-in SQL types, all type conversions are unambiguous, because the program context determines the Java type to which an SQL datum will be converted.

Table 26–1 is a subset of the information presented in Table 4–3, " Default Mappings Between SQL Types and Java Types" on page 4-13. The table lists the one-to-one type-mapping of the SQL database type to its Java `oracle.sql.*` representation.

Table 26–1 Mapping of SQL Datatypes to Java Classes that Represent SQL Datatypes

SQL Datatype	ORACLE Mapping - Java Classes Representing SQL Datatypes
CHAR	oracle.sql.CHAR
VARCHAR2	oracle.sql.CHAR
DATE	oracle.sql.DATE
DECIMAL	oracle.sql.NUMBER
DOUBLE PRECISION	oracle.sql.NUMBER
FLOAT	oracle.sql.NUMBER
INTEGER	oracle.sql.NUMBER
REAL	oracle.sql.NUMBER
RAW	oracle.sql.RAW
LONG RAW	oracle.sql.RAW
REF CURSOR	java.sql.ResultSet
CLOB LOCATOR	oracle.sql.CLOB
BLOB LOCATOR	oracle.sql.BLOB
BFILE	oracle.sql.BFILE
nested table	oracle.sql.ARRAY
varray	oracle.sql.ARRAY
SQL object value	If there is no entry for the object value in the type map: ■ oracle.sql.STRUCT If there is an entry for the object value in the type map: ■ customized Java class
REF to SQL object type	class that implements oracle.sql.SQLRef, typically by extending oracle.sql.REF

This mapping provides the most efficient conversion between SQL and Java data representations. It stores the usual representations of SQL data as byte arrays. It avoids re-formatting the data or performing character-set conversions (aside from the usual network conversions). It is information-preserving. This "Oracle Mapping" is the most efficient type-mapping for applications that "shovel" data from SQL to Java, or vice versa.

Common Problems

This section describes some common problems that you might encounter while using the Oracle JDBC drivers. These problems include:

Memory Consumption for CHAR Columns Defined as OUT or IN/OUT Variables

In PL/SQL, when a `CHAR` or a `VARCHAR` column is defined as a `OUT` or `IN/OUT` variable, the driver allocates a `CHAR` array of 32512 chars. This can cause a memory consumption problem. Note that `VARCHAR2` columns do not exhibit this behavior.

At previous releases, the solution to the problem was to invoke the `Statement.setMaxFieldSize()` method. A better solution is to use `OracleCallableStatement.registerOutParameter()`.

We encourage you always to call `registerOutParameter(int paramIndex, int sqlType, int scale, int maxLength)` on each `CHAR` or `VARCHAR` column. This method is defined in `oracle.jdbc.driver.OracleCallableStatement`. Use the fourth argument, `maxLength`, to limit the memory consumption. `maxLength` tells the driver how many characters are necessary to store this column. The column will be truncated if the character array cannot hold the column data. The third argument, `scale`, is ignored by the driver.

Memory Leaks and Running Out of Cursors

If you receive messages that you are running out of cursors or that you are running out of memory, make sure that all your `Statement` and `ResultSet` objects are explicitly closed. The Oracle JDBC drivers do not have finalizer methods. They perform cleanup routines by using the `close()` method of the `ResultSet` and `Statement` classes. If you do not explicitly close your result set and statement objects, significant memory leaks can occur. You could also run out of cursors in the database. Closing a result set or statement releases the corresponding cursor in the database.

Similarly, you must explicitly close `Connection` objects to avoid leaking and running out of cursors on the server side. When you close the connection, the JDBC driver closes any open statement objects associated with it, thus releasing the cursor objects on the server side.

Boolean Parameters in PL/SQL Stored Procedures

Due to a restriction in the OCI layer, the JDBC drivers do not support the passing of `BOOLEAN` parameters to PL/SQL stored procedures. If a PL/SQL procedure contains `BOOLEAN` values, you can work around the restriction by wrapping the PL/SQL procedure with a second PL/SQL procedure that accepts the argument as an `INT` and passes it to the first stored procedure. When the second procedure is called, the server performs the conversion from `INT` to `BOOLEAN`.

The following is an example of a stored procedure, `BOOLPROC`, that attempts to pass a `BOOLEAN` parameter, and a second procedure, `BOOLWRAP`, that performs the substitution of an `INT` value for the `BOOLEAN`.

```
CREATE OR REPLACE PROCEDURE boolproc(x boolean)
AS
BEGIN
[...]
END;

CREATE OR REPLACE PROCEDURE boolwrap(x int)
AS
BEGIN
IF (x=1) THEN
  boolproc(TRUE);
ELSE
  boolproc(FALSE);
END IF;
END;

// Create the database connection from a DataSource
OracleDataSource ods = new OracleDataSource();
ods.setURL("jdbc:oracle:oci:@<...hoststring...>");
ods.setUser("scott");
ods.setPassword("tiger");
Connection conn = ods.getConnection();
CallableStatement cs = conn.prepareCall ("begin boolwrap(?); end;");
cs.setInt(1, 1);
cs.execute ();
```

Opening More Than 16 OCI Connections for a Process

You might find that you are not able to open more than approximately 16 JDBC-OCI connections for a process at any given time. The most likely reasons for this would be either that the number of processes on the server exceeded the limit specified in the initialization file, or that the per-process file descriptors limit was exceeded. It is important to note that one JDBC-OCI connection can use more than one file descriptor (it might use anywhere between 3 and 4 file descriptors).

If the server allows more than 16 processes, then the problem could be with the per-process file descriptor limit. The possible solution would be to increase this limit.

Basic Debugging Procedures

This section describes strategies for debugging a JDBC program:

- Oracle Net Tracing to Trap Network Events
- Third Party Debugging Tools

For information about processing SQL exceptions, including printing stack traces to aid in debugging, see "Processing SQL Exceptions" on page 4-25.

Oracle Net Tracing to Trap Network Events

You can enable client and server Oracle-Net trace to trap the packets sent over Oracle Net. You can use client-side tracing only for the JDBC OCI driver; it is not supported for the JDBC Thin driver. You can find more information on tracing and reading trace files in the *Oracle Net Services Administrator's Guide*.

The trace facility produces a detailed sequence of statements that describe network events as they execute. "Tracing" an operation lets you obtain more information on the internal operations of the event. This information is output to a readable file that

identifies the events that led to the error. Several Oracle Net parameters in the SQLNET.ORA file control the gathering of trace information. After setting the parameters in SQLNET.ORA, you must make a new connection for tracing to be performed.

The higher the trace level, the more detail is captured in the trace file. Because the trace file can be hard to understand, start with a trace level of 4 when enabling tracing. The first part of the trace file contains connection handshake information, so look beyond this for the SQL statements and error messages related to your JDBC program.

> **Note:** The trace facility uses a large amount of disk space and might have significant impact upon system performance. Therefore, enable tracing only when necessary.

Client-Side Tracing

Set the following parameters in the SQLNET.ORA file on the client system.

TRACE_LEVEL_CLIENT

Purpose:

Turns tracing on/off to a certain specified level.

Default Value:

0 or OFF

Available Values:

- 0 or OFF - No trace output
- 4 or USER - User trace information
- 10 or ADMIN - Administration trace information
- 16 or SUPPORT - WorldWide Customer Support trace information

Example:

TRACE_LEVEL_CLIENT=10

TRACE_DIRECTORY_CLIENT

Purpose:

Specifies the destination directory of the trace file.

Default Value:

ORACLE_HOME/network/trace

Example:

UNIX: TRACE_DIRECTORY_CLIENT=/oracle/traces

Windows: TRACE_DIRECTORY_CLIENT=C:\ORACLE\TRACES

TRACE_FILE_CLIENT

Purpose:

Specifies the name of the client trace file.

Default Value:

`SQLNET.TRC`

Example:

```
TRACE_FILE_CLIENT=cli_Connection1.trc
```

> **Note:** Ensure that the name you choose for the `TRACE_FILE_CLIENT` file is different from the name you choose for the `TRACE_FILE_SERVER` file.

TRACE_UNIQUE_CLIENT

Purpose:

Gives each client-side trace a unique name to prevent each trace file from being overwritten with the next occurrence of a client trace. The PID is attached to the end of the file name.

Default Value:

`OFF`

Example:

```
TRACE_UNIQUE_CLIENT = ON
```

Server-Side Tracing

Set the following parameters in the `SQLNET.ORA` file on the server system. Each connection will generate a separate file with a unique file name.

TRACE_LEVEL_SERVER

Purpose:

Turns tracing on/off to a certain specified level.

Default Value:

0 or `OFF`

Available Values:

- 0 or `OFF` - No trace output
- 4 or `USER` - User trace information
- 10 or `ADMIN` - Administration trace information
- 16 or `SUPPORT` - WorldWide Customer Support trace information

Example:

```
TRACE_LEVEL_SERVER=10
```

TRACE_DIRECTORY_SERVER

Purpose:

Specifies the destination directory of the trace file.

Default Value:

ORACLE_HOME/network/trace

Example:

```
TRACE_DIRECTORY_SERVER=/oracle/traces
```

TRACE_FILE_SERVER

Purpose:

Specifies the name of the server trace file.

Default Value:

SERVER.TRC

Example:

```
TRACE_FILE_SERVER= svr_Connection1.trc
```

> **Note:** Ensure that the name you choose for the TRACE_FILE_SERVER file is different from the name you choose for the TRACE_FILE_CLIENT file.

Third Party Debugging Tools

You can use tools such as JDBCSpy and JDBCTest from Intersolv to troubleshoot at the JDBC API level. These tools are similar to ODBCSpy and ODBCTest.

Transaction Isolation Levels and Access Modes

Read-only connections are supported by the Oracle server, but not by the Oracle JDBC drivers.

For transactions, the Oracle server supports only the TRANSACTION_READ_COMMITTED and TRANSACTION_SERIALIZABLE transaction isolation levels. The default is TRANSACTION_READ_COMMITTED. Use the following methods of the oracle.jdbc.OracleConnection interface to get and set the level:

- getTransactionIsolation(): Gets this connection's current transaction isolation level.
- setTransactionIsolation(): Changes the transaction isolation level, using one of the TRANSACTION_* values.

A

JDBC Error Messages

This appendix briefly discusses the general structure of JDBC error messages, then lists general JDBC error messages and TTC error messages that the Oracle JDBC drivers can return. The appendix is organized as follows:

- General Structure of JDBC Error Messages
- General JDBC Messages
- HeteroRM XA Messages
- TTC Messages

Each of the message lists is first sorted by `ORA` number, and then alphabetically.

For general information about processing JDBC exceptions, see "Processing SQL Exceptions" on page 4-25.

General Structure of JDBC Error Messages

The general JDBC error message structure allows runtime information to be appended to the end of a message, following a colon, as follows:

```
<error_message>:<extra_info>
```

For example, a "closed statement" error might be output as follows:

```
Closed Statement:next
```

This indicates that the exception was thrown during a call to the `next()` method (of a result set object).

In some cases, the user can find the same information in a stack trace.

General JDBC Messages

This section lists general JDBC error messages, first sorted by ORA number, and then alphabetically.

JDBC Messages Sorted by ORA Number

ORA Number	Message
ORA-17001	Internal Error
ORA-17002	Io exception
ORA-17003	Invalid column index
ORA-17004	Invalid column type
ORA-17005	Unsupported column type
ORA-17006	Invalid column name
ORA-17007	Invalid dynamic column
ORA-17008	Closed Connection
ORA-17009	Closed Statement
ORA-17010	Closed Resultset
ORA-17011	Exhausted Resultset
ORA-17012	Parameter Type Conflict
ORA-17014	ResultSet.next was not called
ORA-17015	Statement was cancelled
ORA-17016	Statement timed out
ORA-17017	Cursor already initialized
ORA-17018	Invalid cursor
ORA-17019	Can only describe a query
ORA-17020	Invalid row prefetch
ORA-17021	Missing defines
ORA-17022	Missing defines at index
ORA-17023	Unsupported feature
ORA-17024	No data read
ORA-17025	Error in defines.isNull ()
ORA-17026	Numeric Overflow
ORA-17027	Stream has already been closed
ORA-17028	Can not do new defines until the current ResultSet is closed
ORA-17029	setReadOnly: Read-only connections not supported
ORA-17030	READ_COMMITTED and SERIALIZABLE are the only valid transaction levels
ORA-17031	setAutoClose: Only support auto close mode on
ORA-17032	cannot set row prefetch to zero
ORA-17033	Malformed SQL92 string at position

ORA Number	Message
ORA-17034	Non supported SQL92 token at position
ORA-17035	Character Set Not Supported !!
ORA-17036	exception in OracleNumber
ORA-17037	Fail to convert between UTF8 and UCS2
ORA-17038	Byte array not long enough
ORA-17039	Char array not long enough
ORA-17040	Sub Protocol must be specified in connection URL
ORA-17041	Missing IN or OUT parameter at index:
ORA-17042	Invalid Batch Value
ORA-17043	Invalid stream maximum size
ORA-17044	Internal error: Data array not allocated
ORA-17045	Internal error: Attempt to access bind values beyond the batch value
ORA-17046	Internal error: Invalid index for data access
ORA-17047	Error in Type Descriptor parse
ORA-17048	Undefined type
ORA-17049	Inconsistent java and sql object types
ORA-17050	no such element in vector
ORA-17051	This API cannot be be used for non-UDT types
ORA-17052	This ref is not valid
ORA-17053	The size is not valid
ORA-17054	The LOB locator is not valid
ORA-17055	Invalid character encountered in
ORA-17056	Non supported character set (add orai18n.jar in your classpath)
ORA-17057	Closed LOB
ORA-17058	Internal error: Invalid NLS Conversion ratio
ORA-17059	Fail to convert to internal representation
ORA-17060	Fail to construct descriptor
ORA-17061	Missing descriptor
ORA-17062	Ref cursor is invalid
ORA-17063	Not in a transaction
ORA-17064	Invalid Sytnax or Database name is null
ORA-17065	Conversion class is null
ORA-17066	Access layer specific implementation needed
ORA-17067	Invalid Oracle URL specified
ORA-17068	Invalid argument(s) in call
ORA-17069	Use explicit XA call
ORA-17070	Data size bigger than max size for this type

ORA Number	Message
ORA-17071	Exceeded maximum VARRAY limit
ORA-17072	Inserted value too large for column
ORA-17073	Logical handle no longer valid
ORA-17074	invalid name pattern
ORA-17075	Invalid operation for forward only resultset
ORA-17076	Invalid operation for read only resultset
ORA-17077	Fail to set REF value
ORA-17078	Cannot do the operation as connections are already opened
ORA-17079	User credentials doesn't match the existing ones
ORA-17080	invalid batch command
ORA-17081	error occurred during batching
ORA-17082	No current row
ORA-17083	Not on the insert row
ORA-17084	Called on the insert row
ORA-17085	Value conflicts occurs
ORA-17086	Undefined column value on the insert row
ORA-17087	Ignored performance hint: setFetchDirection()
ORA-17088	Unsupported syntax for requested resultset type and concurrency level
ORA-17089	internal error
ORA-17090	operation not allowed
ORA-17091	Unable to create resultset at the requested type and/or concurrency level
ORA-17092	JDBC statements cannot be created or executed at end of call processing
ORA-17093	OCI operation returned OCI_SUCCESS_WITH_INFO
ORA-17094	Object type version mismatched
ORA-17095	Statement Caching is not enabled for this Connection object
ORA-17096	Statement Caching cannot be enabled for this logical connection
ORA-17097	Invalid PL/SQL Index Table element type
ORA-17098	Invalid empty lob operation
ORA-17099	Invalid PL/SQL Index Table array length
ORA-17100	Invalid database Java Object
ORA-17101	Invalid properties in OCI Connection Pool Object
ORA-17102	Bfile is read only
ORA-17103	invalid connection type to return via getConnection. Use getJavaSqlConnection instead
ORA-17104	SQL statement to execute cannot be empty or null
ORA-17105	connection session time zone was not set

ORA Number	Message
ORA-17106	invalid combination of connections specified
ORA-17107	invalid proxy type specified
ORA-17108	No max length specified in defineColumnType
ORA-17109	standard Java character encoding not found
ORA-17110	execution completed with warning
ORA-17111	Invalid connection cache TTL timeout specified
ORA-17112	Invalid thread interval specified
ORA-17113	Thread interval value is more than the cache timeout value
ORA-17114	could not use local transaction commit in a global transaction
ORA-17115	could not use local transaction rollback in a global transaction
ORA-17116	could not turn on auto-commit in an active global transaction
ORA-17117	could not set savepoint in an active global transaction
ORA-17118	could not obtain ID for a named Savepoint
ORA-17119	could not obtain name for an un-named Savepoint
ORA-17120	could not set a Savepoint with auto-commit on
ORA-17121	could not rollback to a Savepoint with auto-commit on
ORA-17122	could not rollback to a local txn Savepoint in a global transaction
ORA-17123	Invalid statement cache size specified
ORA-17124	Invalid connection cache Inactivity timeout specified
ORA-17125	Improper statement type returned by explicit cache
ORA-17126	Fixed Wait timeout elapsed
ORA-17127	Invalid Fixed Wait timeout specified

JDBC Messages Sorted Alphabetically

ORA Number	Message
ORA-17066	Access layer specific implementation needed
ORA-17102	Bfile is read only
ORA-17038	Byte array not long enough
ORA-17084	Called on the insert row
ORA-17028	Can not do new defines until the current ResultSet is closed
ORA-17019	Can only describe a query
ORA-17078	Cannot do the operation as connections are already opened
ORA-17032	cannot set row prefetch to zero
ORA-17039	Char array not long enough
ORA-17035	Character Set Not Supported !!
ORA-17008	Closed Connection

ORA Number	Message
ORA-17057	Closed LOB
ORA-17010	Closed Resultset
ORA-17009	Closed Statement
ORA-17105	connection session time zone was not set
ORA-17065	Conversion class is null
ORA-17118	could not obtain ID for a named Savepoint
ORA-17119	could not obtain name for an un-named Savepoint
ORA-17122	could not rollback to a local txn Savepoint in a global transaction
ORA-17121	could not rollback to a Savepoint with auto-commit on
ORA-17120	could not set a Savepoint with auto-commit on
ORA-17117	could not set savepoint in an active global transaction
ORA-17116	could not turn on auto-commit in an active global transaction
ORA-17114	could not use local transaction commit in a global transaction
ORA-17115	could not use local transaction rollback in a global transaction
ORA-17017	Cursor already initialized
ORA-17070	Data size bigger than max size for this type
ORA-17025	Error in defines.isNull ()
ORA-17047	Error in Type Descriptor parse
ORA-17081	error occurred during batching
ORA-17071	Exceeded maximum VARRAY limit
ORA-17036	exception in OracleNumber
ORA-17110	execution completed with warning
ORA-17011	Exhausted Resultset
ORA-17060	Fail to construct descriptor
ORA-17037	Fail to convert between UTF8 and UCS2
ORA-17059	Fail to convert to internal representation
ORA-17077	Fail to set REF value
ORA-17126	Fixed Wait timeout elapsed
ORA-17087	Ignored performance hint: setFetchDirection()
ORA-17125	Improper statement type returned by explicit cache
ORA-17049	Inconsistent java and sql object types
ORA-17072	Inserted value too large for column
ORA-17089	internal error
ORA-17001	Internal Error
ORA-17045	Internal error: Attempt to access bind values beyond the batch value
ORA-17044	Internal error: Data array not allocated
ORA-17046	Internal error: Invalid index for data access

ORA Number	Message
ORA-17058	Internal error: Invalid NLS Conversion ratio
ORA-17068	Invalid argument(s) in call
ORA-17080	invalid batch command
ORA-17042	Invalid Batch Value
ORA-17055	Invalid character encountered in
ORA-17003	Invalid column index
ORA-17006	Invalid column name
ORA-17004	Invalid column type
ORA-17106	invalid combination of connections specified
ORA-17124	Invalid connection cache Inactivity timeout specified
ORA-17111	Invalid connection cache TTL timeout specified
ORA-17103	invalid connection type to return via getConnection. Use getJavaSqlConnection instead
ORA-17018	Invalid cursor
ORA-17100	Invalid database Java Object
ORA-17007	Invalid dynamic column
ORA-17098	Invalid empty lob operation
ORA-17127	Invalid Fixed Wait timeout specified
ORA-17074	invalid name pattern
ORA-17075	Invalid operation for forward only resultset
ORA-17076	Invalid operation for read only resultset
ORA-17067	Invalid Oracle URL specified
ORA-17099	Invalid PL/SQL Index Table array length
ORA-17097	Invalid PL/SQL Index Table element type
ORA-17101	Invalid properties in OCI Connection Pool Object
ORA-17107	invalid proxy type specified
ORA-17020	Invalid row prefetch
ORA-17123	Invalid statement cache size specified
ORA-17043	Invalid stream maximum size
ORA-17064	Invalid Sytnax or Database name is null
ORA-17112	Invalid thread interval specified
ORA-17002	Io exception
ORA-17092	JDBC statements cannot be created or executed at end of call processing
ORA-17073	Logical handle no longer valid
ORA-17033	Malformed SQL92 string at position
ORA-17021	Missing defines
ORA-17022	Missing defines at index
ORA-17061	Missing descriptor

ORA Number	Message
ORA-17041	Missing IN or OUT parameter at index:
ORA-17082	No current row
ORA-17024	No data read
ORA-17108	No max length specified in defineColumnType
ORA-17050	no such element in vector
ORA-17056	Non supported character set
ORA-17034	Non supported SQL92 token at position
ORA-17063	Not in a transaction
ORA-17083	Not on the insert row
ORA-17026	Numeric Overflow
ORA-17094	Object type version mismatched
ORA-17093	OCI operation returned OCI_SUCCESS_WITH_INFO
ORA-17090	operation not allowed
ORA-17012	Parameter Type Conflict
ORA-17030	READ_COMMITTED and SERIALIZABLE are the only valid transaction levels
ORA-17062	Ref cursor is invalid
ORA-17014	ResultSet.next was not called
ORA-17031	setAutoClose: Only support auto close mode on
ORA-17029	setReadOnly: Read-only connections not supported
ORA-17104	SQL statement to execute cannot be empty or null
ORA-17109	standard Java character encoding not found
ORA-17096	Statement Caching cannot be enabled for this logical connection
ORA-17095	Statement Caching is not enabled for this Connection object
ORA-17016	Statement timed out
ORA-17015	Statement was cancelled
ORA-17027	Stream has already been closed
ORA-17040	Sub Protocol must be specified in connection URL
ORA-17054	The LOB locator is not valid
ORA-17053	The size is not valid
ORA-17051	This API cannot be be used for non-UDT types
ORA-17052	This ref is not valid
ORA-17113	Thread interval value is more than the cache timeout value
ORA-17091	Unable to create resultset at the requested type and/or concurrency level
ORA-17086	Undefined column value on the insert row
ORA-17048	Undefined type
ORA-17005	Unsupported column type
ORA-17023	Unsupported feature

ORA Number	Message
ORA-17088	Unsupported syntax for requested resultset type and concurrency level
ORA-17069	Use explicit XA call
ORA-17079	User credentials doesn't match the existing ones
ORA-17085	Value conflicts occurs

HeteroRM XA Messages

The following are the JDBC error messages that are specific to the HeteroRM XA feature.

HeteroRM XA Messages Sorted by ORA Number

ORA Number	Message
ORA-17200	Unable to properly convert XA open string from Java to C
ORA-17201	Unable to properly convert XA close string from Java to C
ORA-17202	Unable to properly convert RM name from Java to C
ORA-17203	Could not cast pointer type to jlong
ORA-17204	Input array too short to hold OCI handles
ORA-17205	Failed to obtain OCISvcCtx handle from C-XA using xaoSvcCtx
ORA-17206	Failed to obtain OCIEnv handle from C-XA using xaoEnv
ORA-17207	The tnsEntry property was not set in DataSource
ORA-17213	C-XA returned XAER_RMERR during xa_open
ORA-17215	C-XA returned XAER_INVAL during xa_open
ORA-17216	C-XA returned XAER_PROTO during xa_open
ORA-17233	C-XA returned XAER_RMERR during xa_close
ORA-17235	C-XA returned XAER_INVAL during xa_close
ORA-17236	C-XA returned XAER_PROTO during xa_close

HeteroRM XA Messages Sorted Alphabetically

ORA Number	Message
ORA-17203	Could not cast pointer type to jlong
ORA-17235	C-XA returned XAER_INVAL during xa_close
ORA-17215	C-XA returned XAER_INVAL during xa_open
ORA-17236	C-XA returned XAER_PROTO during xa_close
ORA-17216	C-XA returned XAER_PROTO during xa_open
ORA-17233	C-XA returned XAER_RMERR during xa_close
ORA-17213	C-XA returned XAER_RMERR during xa_open
ORA-17206	Failed to obtain OCIEnv handle from C-XA using xaoEnv

ORA Number	Message
ORA-17205	Failed to obtain OCISvcCtx handle from C-XA using xaoSvcCtx
ORA-17204	Input array too short to hold OCI handles
ORA-17207	The tnsEntry property was not set in DataSource
ORA-17202	Unable to properly convert RM name from Java to C
ORA-17201	Unable to properly convert XA close string from Java to C
ORA-17200	Unable to properly convert XA open string from Java to C

TTC Messages

This section lists TTC error messages, first sorted by ORA number, and then alphabetically.

TTC Messages Sorted by ORA Number

ORA Number	Message
ORA-17401	Protocol violation
ORA-17402	Only one RPA message is expected
ORA-17403	Only one RXH message is expected
ORA-17404	Received more RXDs than expected
ORA-17405	UAC length is not zero
ORA-17406	Exceeding maximum buffer length
ORA-17407	invalid Type Representation(setRep)
ORA-17408	invalid Type Representation(getRep)
ORA-17409	invalid buffer length
ORA-17410	No more data to read from socket
ORA-17411	Data Type representations mismatch
ORA-17412	Bigger type length than Maximum
ORA-17413	Exceding key size
ORA-17414	Insufficient Buffer size to store Columns Names
ORA-17415	This type hasn't been handled
ORA-17416	FATAL
ORA-17417	NLS Problem, failed to decode column names
ORA-17418	Internal structure's field length error
ORA-17419	Invalid number of columns returned
ORA-17420	Oracle Version not defined
ORA-17421	Types or Connection not defined
ORA-17422	Invalid class in factory
ORA-17423	Using a PLSQL block without an IOV defined
ORA-17424	Attempting different marshaling operation

ORA Number	Message
ORA-17425	Returning a stream in PLSQL block
ORA-17426	Both IN and OUT binds are NULL
ORA-17427	Using Uninitialized OAC
ORA-17428	Logon must be called after connect
ORA-17429	Must be at least connected to server
ORA-17430	Must be logged on to server
ORA-17431	SQL Statement to parse is null
ORA-17432	invalid options in all7
ORA-17433	invalid arguments in call
ORA-17434	not in streaming mode
ORA-17435	invalid number of in_out_binds in IOV
ORA-17436	invalid number of outbinds
ORA-17437	Error in PLSQL block IN/OUT argument(s)
ORA-17438	Internal - Unexpected value
ORA-17439	Invalid SQL type
ORA-17440	DBItem/DBType is null
ORA-17441	Oracle Version not supported. Minimum supported version is 7.2.3.
ORA-17442	Refcursor value is invalid
ORA-17443	Null user or password not supported in THIN driver
ORA-17444	TTC Protocol version received from server not supported

TTC Messages Sorted Alphabetically

ORA Number	Message
ORA-17424	Attempting different marshaling operation
ORA-17412	Bigger type length than Maximum
ORA-17426	Both IN and OUT binds are NULL
ORA-17411	Data Type representations mismatch
ORA-17440	DBItem/DBType is null
ORA-17437	Error in PLSQL block IN/OUT argument(s)
ORA-17413	Exceding key size
ORA-17406	Exceeding maximum buffer length
ORA-17416	FATAL
ORA-17414	Insufficient Buffer size to store Columns Names
ORA-17438	Internal - Unexpected value
ORA-17418	Internal structure's field length error
ORA-17433	invalid arguments in call
ORA-17409	invalid buffer length

ORA Number	Message
ORA-17422	Invalid class in factory
ORA-17419	Invalid number of columns returned
ORA-17435	invalid number of in_out_binds in IOV
ORA-17436	invalid number of outbinds
ORA-17432	invalid options in all7
ORA-17439	Invalid SQL type
ORA-17408	invalid Type Representation(getRep)
ORA-17407	invalid Type Representation(setRep)
ORA-17428	Logon must be called after connect
ORA-17429	Must be at least connected to server
ORA-17430	Must be logged on to server
ORA-17417	NLS Problem, failed to decode column names
ORA-17410	No more data to read from socket
ORA-17434	not in streaming mode
ORA-17443	Null user or password not supported in THIN driver
ORA-17402	Only one RPA message is expected
ORA-17403	Only one RXH message is expected
ORA-17420	Oracle Version not defined
ORA-17441	Oracle Version not supported. Minimum supported version is 7.2.3.
ORA-17401	Protocol violation
ORA-17404	Received more RXDs than expected
ORA-17442	Refcursor value is invalid
ORA-17425	Returning a stream in PLSQL block
ORA-17431	SQL Statement to parse is null
ORA-17415	This type hasn't been handled
ORA-17444	TTC Protocol version received from server not supported
ORA-17421	Types or Connection not defined
ORA-17405	UAC length is not zero
ORA-17423	Using a PLSQL block without an IOV defined
ORA-17427	Using Uninitialized OAC

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