Oracle® Fusion Middleware

Reference for Oracle Security Developer Tools

11*g* Release 1 (11.1.1)

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Oracle Fusion Middleware Reference for Oracle Security Developer Tools, 11*g* Release 1 (11.1.1)

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Preface

The *Oracle Fusion Middleware Reference for Oracle Security Developer Tools* provides reference information about the Oracle Security Developer Tools. This Preface contains the following topics:

- Intended Audience
- Documentation Accessibility
- Related Documents
- Conventions

Intended Audience

Oracle Fusion Middleware Reference for Oracle Security Developer Tools is intended for Java developers responsible for developing secure applications. This documentation assumes programming proficiency using Java, and familiarity with security concepts such as cryptography, public key infrastructure, Web services security, and identity federation.

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Related Documents

For more information, see the following documentation available in the Oracle Fusion Middleware 11*g* Release 1 (11.1.1) documentation set:

- *Oracle Fusion Middleware Security Overview*
- *Oracle Fusion Middleware Security Guide*
- *Oracle Identity Management User Reference*

Conventions

The following text conventions are used in this document:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
italic	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
`monospace`	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

What's New in Oracle Security Developer Tools?

This preface introduces the new and changed features of Oracle Security Developer Tools 11*g* Release 1 (11.1.1). This information is primarily useful for users who have developed applications with the tools in previous releases of Oracle Application Server, including Oracle Application Server 10*g* Release 2 (10.1.2.0.2) and Oracle Application Server 10*g* (10.1.4.0.1).

Topics in this section include:

- New Features for Release 11g (11.1.1)
- Oracle SAML Changes

New Features for Release 11*g* (11.1.1)

The new features of Oracle Security Developer Tools include the following:

- All higher level toolkits now take JCE keys and certificates as parameters instead of Oracle crypto keys and certificates.

  This lets you use any JCE provider, in particular a hardware-based JCE provider.

  > **Note:** Due to this change, the 11*g* Release 1 (11.1.1) APIs are not compatible with pre-11*g* Release 1 (11.1.1). Your existing code will need to be changed to compile with 11*g* Release 1 (11.1.1) Oracle Security Developer Tools.

- Support for Web Services Security 1.1. This includes:
  - implementation of Kerberos and SAML 2.0 profiles
  - WS-i BSP conformance
- Upper layers of the toolkit hierarchy that called the Oracle Security Engine now call the new JCE Provider for cryptographic functions

  Figure 1–2 on page 1-11 depicts the relationships between tools in the toolkit.

Oracle SAML Changes

Oracle Fusion Middleware 11g contains updates to most classes in the SAML2 library. The fixes fall into a few broad categories:

- Schema Errors
- Extraneous Namespace Declarations
- Missing Namespace Declarations
- Extraneous xsi:type Declarations
- Incomplete Support for Boolean Types

Schema Errors

These include issues such as incorrectly spelled XML element or attribute names, incorrect namespace URIs, or incorrect ordering of child elements.

Extraneous Namespace Declarations

Many classes were outputting both a default declaration and a prefix-bound declaration for the same namespace. This causes issues for some XML parsers and SOAP implementations, which can cause XML signature verification errors in some 3rd-party SAML software.

The fixes remove the extra default namespace declarations, leaving only the prefix-bound declarations.

Missing Namespace Declarations

Some of the SAML classes needed to have a namespace prefix declared.

Extraneous xsi:type Declarations

Many classes had both a concrete XML element type name and an `xsi:type` declaration. This is redundant and confusing; only extension XML types should declare the `xsi:type` of the element.

Incomplete Support for Boolean Types

Some classes that implement XML elements with attribute of type `xsd:boolean` recognized only the values "true" and "false", while the values "1" and "0" should also be allowed.

1 Introduction to Oracle Security Developer Tools

Security tools are a critical component for today's application development projects. Commercial requirements and government regulations dictate that sensitive data be kept confidential and protected from tampering or alteration.

Oracle Security Developer Tools provide you with the cryptographic building blocks necessary for developing robust security applications, ranging from basic tasks like secure messaging to more complex projects such as securely implementing a service-oriented architecture. The tools build upon the core foundations of cryptography, public key infrastructure, web services security, and federated identity management.

A wide range of Oracle products utilize the Oracle Security Developer Tools, for example:

- applications such as Oracle BPEL Process Manager and Oracle Collaboration Suite
- Oracle Platform Security Services, which include SSL configuration features for system components, and Oracle Wallet, which is utilized in Oracle Identity Management products, Oracle Enterprise Manager, and Oracle Database Server
- system components like Oracle Web Services Manager (OWSM); Business Integration (B2B); Oracle Portal; and Oracle Identity Federation

This chapter takes a closer look at these underlying security technologies and introduces the components of the Oracle Security Developer Tools. It covers these topics:

- Cryptography
- Public Key Infrastructure (PKI)
- Web Services Security
- SAML
- Federation
- Overview of Oracle Security Developer Tools

1.1 Cryptography

As data travels across untrusted communication channels, cryptography protects the transmitted messages from being intercepted (a passive attack) or modified (an active attack) by an intruder. To protect the message, an originator uses a cryptographic tool to convert plain, readable messages or **plaintext** into encrypted **ciphertext**. While the original text is present, its appearance changes into a form that is unintelligible if intercepted. The message recipient likewise uses a cryptographic tool to decrypt the ciphertext into its original readable format.

Cryptography secures communications over a network such as the internet by providing:

- Authentication, which assures the receiver that the information is coming from a trusted source. Authentication is commonly achieved through the use of a Message Authentication Code (**MAC**), **digital signature**, and **digital certificate**.
- Confidentiality, which ensures that only the intended receiver can read a message. Confidentiality is commonly attained through encryption.
- Integrity, which ensures that the received message has not been altered from the original. Integrity is commonly ensured by using a cryptographic hash function.
- Non-repudiation, which is a way to prove that a given sender actually sent a particular message. Non-repudiation is typically achieved through the use of digital signatures.

1.1.1 Types of Cryptographic Algorithms

The mathematical operations used to map between plaintext and ciphertext are identified by a **cryptographic algorithm** (also known as a **cipher**). Cryptographic algorithms require the text to be mapped, and, at a minimum, require some value which controls the mapping process. This value is called a **key**.

Essentially, there are three types of cryptographic algorithms which can be categorized by the number of keys used for encryption and decryption, and by their application and usage. The basic types of cryptographic algorithms are:

- Symmetric Cryptographic Algorithms
- Asymmetric Cryptographic Algorithms
- Hash Functions

Each type is optimized for certain applications. Hash functions are suited for ensuring data integrity. Symmetric cryptography is ideally suited for encrypting messages. Asymmetric cryptography is used for the secure exchange of keys, authentication, and non-repudiation. Asymmetric cryptography could also be used to encrypt messages, although this is rarely done. Symmetric cryptography operates about 1000 times faster, and is better suited for encryption than asymmetric cryptography.

1.1.1.1 Symmetric Cryptographic Algorithms

A **symmetric cryptography** algorithm (also known as **secret key cryptography**) uses a single key for both encryption and decryption. The sender uses the key to encrypt the plaintext and sends the ciphertext to the receiver. The receiver applies the same key to decrypt the message and recover the plaintext. The key must be known to both the sender and receiver. The biggest problem with symmetric cryptography is the secure distribution of the key.

Symmetric cryptography schemes are generally categorized as being either a **block cipher** or **stream cipher**. A block cipher encrypts one fixed-size block of data (usually 64 bits) at a time using the same key on each block. Some common block ciphers used today include **Blowfish**, **AES**, **DES**, and **3DES**.

Stream ciphers operate on a single bit at a time and implement some form of feedback mechanism so that the key is constantly changing. **RC4** is an example of a stream cipher that is used for secure communications using the SSL protocol.

1.1.1.2 Asymmetric Cryptographic Algorithms

An **asymmetric cryptography** algorithm (also known as **public key cryptography**) uses one key to encrypt the plaintext and another key to decrypt the ciphertext. It does not matter which key is applied first, but both keys are required for the process to work.

In asymmetric cryptography, one of the keys is designated the **public key** and is made widely available. The other key is designated the **private key** and is never revealed to another party. To send messages under this scheme, the sender encrypts some information using the receiver’s public key. The receiver then decrypts the ciphertext using her private key. This method can also be used to prove who sent a message (non-repudiation). The sender can encrypt some plaintext with her private key, and when the receiver decrypts the message with the sender’s public key, the receiver knows that the message was indeed sent by that sender.

Some of the common asymmetric algorithms in use today are **RSA**, **DSA**, and **Diffie-Hellman**.

1.1.1.3 Hash Functions

A **hash function** (also known as a **message digest**) is a one-way encryption algorithm that essentially uses no key. Instead, a fixed-length hash value is computed based upon the plaintext that makes it impossible for either the contents or length of the plaintext to be recovered. Hash algorithms are typically used to provide a digital fingerprint of a file's contents, often used to ensure that the file has not been altered by an intruder or virus. Hash functions are also commonly employed by many operating systems to encrypt passwords. Hash functions help preserve the integrity of a file. Some common hash functions include **MD2**, **MD4**, **MD5** and **SHA**.

1.1.2 Additional Cryptography Resources

For more information, refer to the cryptography resources listed in Appendix A.

1.2 Public Key Infrastructure (PKI)

A **public key infrastructure (PKI)** is designed to enable secure communications over public and private networks. Besides secure transmission and storage of data, PKI enables secure e-mail, digital signatures, and data integrity.

These facilities are delivered using **public key cryptography**, a mathematical technique that uses a pair of related cryptographic keys to verify the identity of the sender (**digital signature**), or to ensure the privacy of a message (**encryption**). PKI facilities support secure information exchange over insecure networks, such as the Internet.

Critical elements for achieving the goals of PKI include:

- Encryption algorithms and keys to secure communications
- Digital certificates that associate a **public key** with the identity of its owner
- Key distribution methods to permit widespread, secure use of encryption
- A trusted entity, known as a **Certificate Authority (CA)**, to vouch for the relationship between a key and its legitimate owner
- A **Registration Authority (RA)** that is responsible for verifying the information supplied in requests for certificates made to the CA

Relying third parties use the certificates issued by the CA and the public keys contained therein to verify digital certificates and encrypt data.

1.2.1 Key Pairs

Encryption techniques often use a text or number called a **key**, known only to the sender and recipient.

When both use the same key, the encryption scheme is called symmetric. Difficulties with relying on a symmetric system include getting that key to both parties without allowing an eavesdropper to get it, too; and the fact that a separate key is needed for every two people, so that each individual must maintain many keys, one for each recipient.

Public key cryptography uses a **key pair** of mathematically related cryptographic keys - the **public key** and the **private key**. For an explanation of the use of key pairs, see "Asymmetric Cryptographic Algorithms".

Table 1–1 summarizes who uses public and private keys and when:

Table 1–1 Summary of Public and Private Key Usage

Function	Key Type	Whose Key
Encrypt data for a recipient	Public key	Receiver
Sign data	Private key	Sender
Decrypt data received	Private key	Receiver
Verify a signature	Public key	Sender

1.2.2 Certificate Authority

A **Certificate Authority (CA)** is a trusted third party that vouches for the public key owner's identity. Examples of certificate authorities include Verisign and Thawte.

1.2.3 Digital Certificates

The certification authority validates the public key's link to a particular entity by creating a **digital certificate**. This digital certificate contains the public key and information about the key holder and the signing certification authority. Using a PKI certificate to authenticate one's identity is analogous to identifying oneself with a driver's license or passport.

1.2.4 Related PKI Standards

A number of standards and protocols support PKI certificate implementation.

Cryptographic Message Syntax

Cryptographic Message Syntax (CMS) is a general syntax for data protection developed by the **Internet Engineering Task Force (IETF)**. It supports a wide variety of content types including signed data, enveloped data, digests, and encrypted data, among others. CMS allows multiple encapsulation so that, for example, previously signed data can be enveloped by a second party.

Values produced by CMS are encoded using X.509 Basic Encoding Rules (BER), meaning that the values are represented as octet strings.

Secure/Multipurpose Internet Mail Extension

Secure/Multipurpose Internet Mail Extension (S/MIME) is an Internet Engineering Task Force (IETF) standard for securing MIME data through the use of digital signatures and encryption.

S/MIME provides the following cryptographic security services for electronic messaging applications:

- Authentication
- Message integrity and non-repudiation of origin (using digital signatures)
- Privacy and data security (using encryption)

Lightweight Directory Access Protocol

Lightweight Directory Access Protocol (LDAP) is the open standard for obtaining and posting information to commonly used directory servers. In a **public key infrastructure (PKI)** system, a user's **digital certificate** is often stored in an LDAP directory and accessed as needed by requesting applications and services.

Time Stamp Protocol

In a **Time Stamp Protocol (TSP)** system, a trusted third-party Time Stamp Authority (TSA) issues time stamps for digital messages. Time stamping proves that a message was sent by a particular entity at a particular time, providing **non-repudiation** for online transactions.

The Time Stamp Protocol, as specified in RFC 3161, defines the participating entities, the message formats, and the transport protocol involved in time stamping a digital message.

To see how a time-stamping system can work, suppose Sally signs a document and wants it time stamped. She computes a **message digest** of the document using a secure **hash function** and then sends the message digest (but not the document itself) to the TSA, which sends her in return a digital time stamp consisting of the message digest, the date and time it was received at the TSA server, and the signature of the TSA. Since the message digest does not reveal any information about the content of the document, the TSA cannot eavesdrop on the documents it time stamps. Later, Sally can present the document and time stamp together to prove when the document was written. A verifier computes the message digest of the document, makes sure it matches the digest in the time stamp, and then verifies the signature of the TSA on the time stamp.

Online Certificate Status Protocol

Online Certificate Status Protocol (OCSP) is one of two common schemes for checking the validity of digital certificates. The other, older method, which OCSP has superseded in some scenarios, is known as the **certificate revocation list (CRL)**.

OCSP overcomes the chief limitation of CRL: the fact that updates must be frequently down-loaded to keep the list current at the client end. When a user attempts to access a server, OCSP sends a request for certificate status information. The server sends back a response of good, revoked, or unknown. The protocol specifies the syntax for communication between the server (which contains the certificate status) and the client application (which is informed of that status).

Certificate Management Protocol

The **certificate management protocol (CMP)** handles all relevant aspects of certificate creation and management. CMP supports interactions between public key infrastructure (PKI) components, such as Certificate Authorities (CAs), Registration Authorities (RAs), and end entities that are issued certificates.

1.2.5 Benefits of PKI

PKI provides users with the following benefits:

- Secure and reliable authentication of users

  Reliable authentication relies on two factors. The first is proof of possession of the private key part of the public/private pair, which is verified by an automatic procedure that uses the public key. The second factor is validation by a certification authority that a public key belongs to a specific identity. A PKI-based digital certificate validates this identity connection based on the key pair.

- Data integrity

  Using the private key of a public/private key pair to sign digital transactions makes it difficult to alter the data in transit. This "digital signature" is a coded digest of the original message encrypted by the sender’s private key. Recipients can readily use the sender's corresponding public key to verify who sent the message and the fact that it has not been altered. Any change to the message or the digest would have caused the attempted verification using the public key to fail, telling the recipient not to trust it.

- Non-repudiation

  PKI can also be used to prove who sent a message. The sender encrypts some plaintext with her private key to create a digital signature, and when the receiver decrypts the message with the sender’s public key, the receiver knows that the message was indeed sent by that sender, making it difficult for the message originator to disown the message; this capability is known as non-repudiation.

- Prevention of unauthorized access to transmitted or stored information

  The time and effort required to derive the private key from the public key makes it unlikely that the message would be decrypted by anyone other than the key pair owner.

1.3 Web Services Security

Web services provide a standard way for businesses and other organizations to integrate Web-based applications using open standards technologies such as **XML**, **SOAP**, and **WSDL**.

SOAP is a lightweight protocol for exchange of information in a service oriented environment. In such an environment, applications can expose selected functionality (business logic, for example) for use by other applications. SOAP provides the means by which applications supply and consume these services; it is an XML-based protocol for message transport in a distributed, decentralized Web Services application environment.

While the core SOAP specification solves many problems related to XML and Web Services, it does not provide a means to address message security requirements such as confidentiality, integrity, message authentication, and non-repudiation. The need for securing SOAP prompted **OASIS** to put forward the Web Services Security standard, which:

- Specifies enhancements to allow signing and encryption of SOAP messages
- Describes a general-purpose method for associating security tokens with messages

- Provides additional means for describing the characteristics of tokens that are included with a message

1.4 SAML

Security Assertions Markup Language (**SAML**) is an XML-based framework for exchanging security information over the Internet. SAML enables the exchange of authentication and authorization information between various security services systems that otherwise would not be able to interoperate.

The SAML 1.0, 1.1, and 2.0 specifications were adopted by the Organization for the Advancement of Structured Information Standards (OASIS) in 2002, 2003, and 2005 respectively. OASIS is a worldwide not-for-profit consortium that drives the development, convergence, and adoption of e-business standards.

SAML 2.0 marks the convergence of the Liberty ID-FF, Shibboleth, and SAML 1.0/1.1 federation protocols.

1.4.1 SAML Assertions

SAML associates an identity (such as an e-mail address or a directory listing) with a subject (such as a user or system) and defines the access rights within a specific domain. The basic SAML document is the `Assertion`, which contains declarations of facts about a `Subject` (typically a user). SAML provides three kinds of declarations, or `Statements`:

- `AuthnStatement` asserts that the user was authenticated by a particular method at a specific time.
- `AttributeStatement` asserts that the user is associated with particular attributes or details, for example an employee number or account number.
- `AuthzDecisionStatement` asserts that the user's request for a certain access to a particular resource has been allowed or denied.

Assertions are XML documents generated about events that have already occurred. While SAML makes assertions about credentials, it does not actually authenticate or authorize users. Example 1–1 shows a typical SAML authentication assertion wrapped in a SAMLP response message:

Example 1–1 Sample SAMLP Response Containing a SAML 1.0 Authentication Assertion

```
<samlp:Response
       MajorVersion="1" MinorVersion="0"
       ResponseID="128.14.234.20.90123456"
       InResponseTo="123.45.678.90.12345678"
       IssueInstant="2005-12-14T10:00:23Z"
       xmlns:saml="urn:oasis:names:tc:SAML:1.0:assertion"
       xmlns:samlp="urn:oasis:names:tc:SAML:1.0:protocol">
       <samlp:Status>
           <samlp:StatusCode Value="samlp:Success" />
       </samlp:Status>
       <saml:Assertion
           MajorVersion="1" MinorVersion="0"
           AssertionID="123.45.678.90.12345678"
           Issuer="IssuingAuthority.com"
           IssueInstant="2005-12-14T10:00:23Z" >
           <saml:Conditions
               NotBefore="2005-12-14T10:00:30Z"
```

```
            NotAfter="2005-12-14T10:15:00Z" />
        </saml:Conditions
        <saml:AuthenticationStatement
            AuthenticationMethod="urn:oasis:names:tc:SAML:1.0:am:password"
            AuthenticationInstant="2005-12-14T10:00:20Z">
            <saml:Subject>
                <saml:NameIdentifier NameQualifier="RelyingParty.com">
                  john.smith
                </saml:NameIdentifier>
                <saml:SubjectConfirmation>
                    <saml:ConfirmationMethod>
                        urn:oasis:names:tc:SAML:1.0:cm:artifact-01
                    </saml:ConfirmationMethod>
                </saml:SubjectConfirmation>
            </saml:Subject>
        </saml:AuthenticationStatement>
    </saml:Assertion>
</samlp:Response>
```

1.4.2 SAML Requests and Responses

The authority that issues assertions is known as the **issuing authority** or **identity provider**. An issuing authority can be a third-party service provider or an individual business that is serving as an issuing authority within a private federation of businesses. SAML-compliant applications and services, which trust the issuing authority or identity provider and make use of its services, are called **relying parties** or **service provider**s.

1.4.2.1 SAML Request and Response Cycle

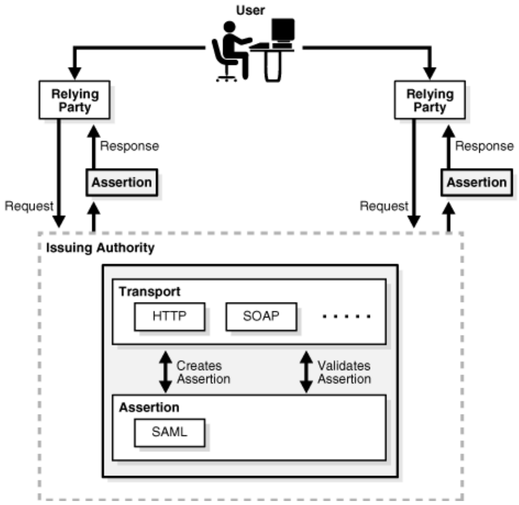
In a typical SAML cycle, the relying party (or service provider), which needs to authenticate a specific client request, sends a SAML request to its issuing authority or identity provider. The identity provider responds with a SAML assertion, which supplies the relying party or service provider with the requested security information.

For example, when a user signs into a SAML-compliant service of a relying party or identity provider, the service sends a "request for authentication assertion" to the issuing authority (identity provider). The issuing authority returns an "authentication assertion" reference stating that the user was authenticated by a particular method at a specific time. The service can then pass this assertion reference to other relying party/identity provider sites to validate the user's credentials. When the user accesses another SAML-compliant site that requires authentication, that site uses the reference to request the "authentication assertion" from the issuing authority or identity provider, which states that the user has already been authenticated.

At the issuing authority, an assertion layer handles request and response messages using the SAML protocol, which can bind to various communication and transport protocols (HTTP, SOAP, and so on). Note that while the client always consumes assertions, the issuing authority or identity provider can act as producer and consumer since it can both create and validate assertions.

This cycle is illustrated in Figure 1–1.

Figure 1–1 SAML Request-Response Cycle



This figure shows a SAML request and response cycle, and shows a user, boxes for relying parties, and a box for the issuing authority. The user or client request first goes to the relying party, which sends a SAML request to its issuing authority. The issuing authority responds with a SAML assertion, which supplies the relying party with the requested security information. Two-way arrows denote the client communication with the relying party (there can be more than one relying party), and also denote the request-response communication between the relying party and issuing authority.

Finally, the box for the issuing authority separates out the assertion layer (SAML) from the transport layer (HTTP, SOAP, and so on) to show that the communication between these layers enables the issuing authority to create and validate assertions.

1.4.2.2 SAML Protocol Bindings and Profiles

SAML defines a protocol for requesting and obtaining assertions (SAMLP). Bindings define the standard way that SAML request and response messages are transported across the issuing authorities (identity providers) and relying parties (identity providers) by providing mappings between SAML messages and standard communication protocols. For example, the defined transport mechanism for SAML requests and responses is Simple Object Access Protocol (SOAP) over HTTP. This enables the exchange of SAML information across several Web services in a standard manner.

A profile describes how SAML assertion and protocol messages are combined with particular transport bindings to achieve a specific practical use case. Among the most widely-implemented SAML profiles, for example, are Web browser profiles for single sign-on and SOAP profiles for securing SOAP payloads.

1.4.2.3 SAML and XML Security

In addition, SAML was designed to integrate with XML Signature and XML Encryption, standards from the World Wide Web Consortium for embedding encrypted data or digital signatures within an **XML** document. This support for XML signatures allows SAML to handle not only authentication, but also message integrity and nonrepudiation of the sender. See Chapter 8 for more information about Oracle XML Security.

1.5 Federation

As global businesses strive for ever-closer relationships with suppliers and customers, they face challenges in creating more intimate, yet highly secure trading relationships.

Parties conducting a business transaction must be certain of the identity of the person or agent with whom they are dealing; they must also be assured that the other has the authority to act on behalf of the business with whom the transaction is being conducted.

Historically, in the course of doing business with partners, companies have resorted to acquiring names, responsibilities, and other pertinent information about all entities who might act on behalf of the partner company. With changing roles and responsibilities, and particularly in large enterprises, this can create significant logistical problems as the data quickly becomes very costly to maintain and manage.

Besides complexity, other challenges include cost control, enabling secure access to resources for employees and customers, and regulatory compliance, among others.

These requirements are driving the move toward Federated Identity Management, in which parties establish trust relationships that allow one party to recognize and rely upon security tokens issued by another party.

Key federation concepts include:

- **Principal** - the key actor in a federated environment, being an entity that performs an authorized business task
- **Identity Provider** - a service that authenticates a Principal's identity
- **Service Provider** - an entity that provides a service to a principal or another entity. For example, a travel agency can act as a Service Provider to a partner's employees (principals).
- **Single Sign-on** - the Principal's ability to authenticate with one system entity (the Identity Provider), and have other entities (the Service Providers) honor that authentication

The Liberty Alliance is an open organization which establishes technology and business standards for Federated Identity Management to facilitate interoperable identity services.

To learn more about this topic, read the white paper Federated Identity Management, which is available on the Oracle Identity Federation page at `http://www.oracle.com/technology/products/id_mgmt/osfs/index.html`.

Note: For additional information about the standards mentioned here, see Appendix A, "References".

1.6 Overview of Oracle Security Developer Tools

This section provides an introduction to the Oracle Security Developer Tools, which are pure java tools that enable you to implement a wide range of security tasks and projects.

1.6.1 Toolkit Architecture

It is useful to consider the tools in the toolkit as a whole, and then to look at functional subsets of tools for different applications.

Overall Architecture

Figure 1–2 The Oracle Security Developer Tools

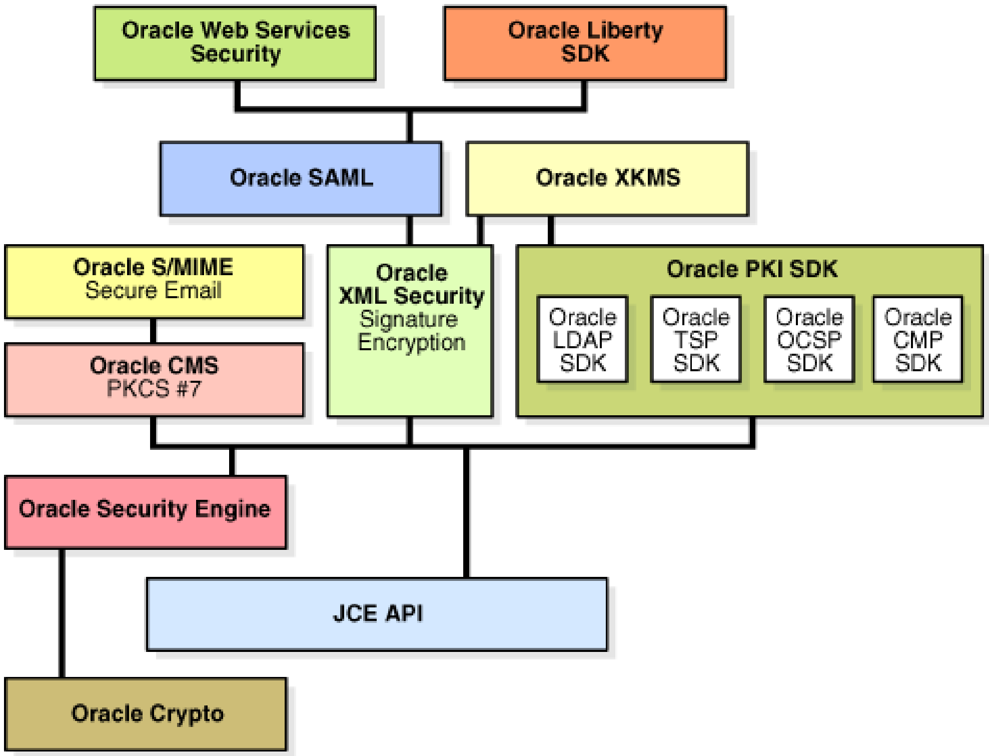


Figure 1–2 shows the components of the Oracle Security Developer Tools. Typically, a tool will utilize functions provided by the tool immediately below it in the stack. For example, the Oracle SAML tool leverages functions provided by the Oracle XML Security tool.

Note that:

- Conceptually, the tools can be considered to be arranged in layers with the fundamental building blocks at the bottom layer; each additional layer utilizes and builds upon the the layer immediately below, to provide tools for specific security applications.
- The figure is not intended as a hierarchy or sequence diagram. Rather, it illustrates the relationship among components and the progression from low-level tools to more specialized and application-specific components higher up the stack.

Oracle Crypto and Oracle Security Engine are the basic cryptographic tools of the set. The next layer consists of Oracle CMS for message syntax, Oracle XML Security for signature encryption, and Oracle PKI SDK, which is a suite of PKI tools consisting of Oracle PKI LDAP SDK, Oracle PKI TSP SDK, Oracle PKI OCSP SDK, and Oracle PKI CMP SDK. Oracle S/MIME exploits Oracle CMS to provide a toolset for secure e-mail. The next layer contains Oracle SAML and Oracle Liberty SDK, which provides structured assertion markup and federated identity management capabilities. Finally, Oracle Web Services Security provides web services security.

For a description of each tool, see these sections:

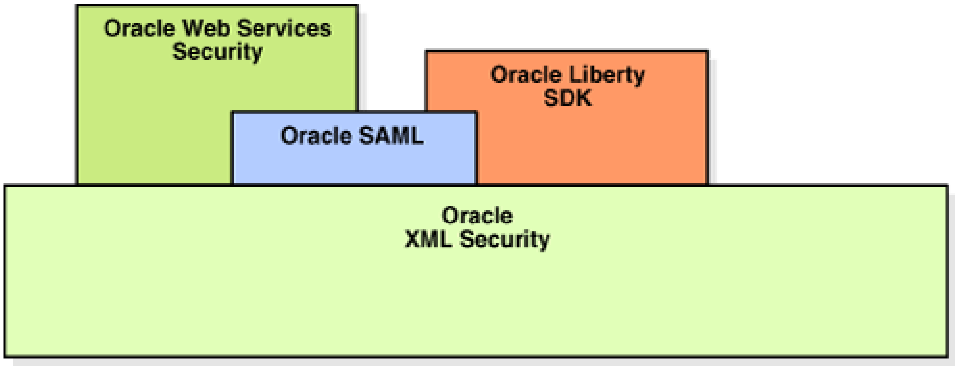
- Oracle Crypto
- Oracle Security Engine

- Oracle CMS
- Oracle S/MIME
- Oracle PKI SDK
- Oracle XML Security
- Oracle SAML
- Oracle Web Services Security
- Oracle Liberty SDK
- Oracle XKMS

Tools for XML, SAML, and Web Services Security Applications

In addition to providing security for XML documents, the Oracle XML Security package provides the foundation for these components of the toolkit:

- Oracle Web Services Security
- Oracle SAML for developing SAML 1.0 and 2.0-compliant Java security services
- Oracle Liberty SDK for single sign-on (SSO) and federated identity applications based on Liberty Alliance specifications

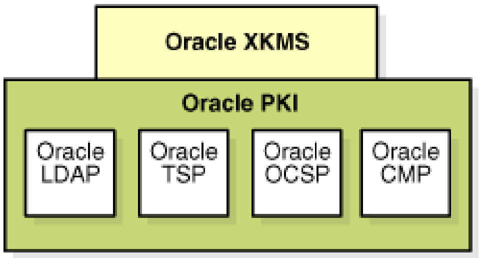


This graphic shows that Oracle SAML, Oracle Web Services Security, and Oracle Liberty tools are built on Oracle XML Security.

> **Note:** A diagram like this is necessarily simplified; in practice the jar relationships between the Oracle Security Developer Tools are complex and dependent upon implementation details. For example, to use the SAML libraries, you actually need several components:
>
> - The Oracle XML Security library is needed as SAML requires signatures.
> - Oracle Security Engine provides certificate and CRL management features
>
> See Figure 1–2, "The Oracle Security Developer Tools" for a more complete picture of dependencies. See the subsequent tool chapters in this guide for instructions on setting up the classpath for each tool, so that you have the correct environment for each type of application.

Tools for Public Key Cryptography (PKI) Applications

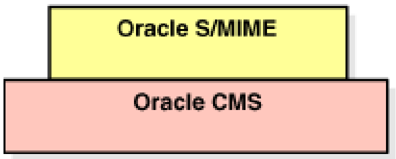
The Oracle PKI package consists of tools for working with digital certificates within an LDAP repository, for developing timestamp services conforming to RFC 3161, for OCSP messaging compliant with RFC 2560, and tools for the certificate management protocol (CMP) specification. The Oracle PKI package also provides the foundation for Oracle XKMS, which enables you to develop XML transactions for digital signature processing.



This graphic shows that Oracle's XKMS tool is built on Oracle PKI tools, which consist of Oracle LDAP, Oracle TSP, Oracle OCSP, and Oracle CMP.

Tools for E-mail Security Applications

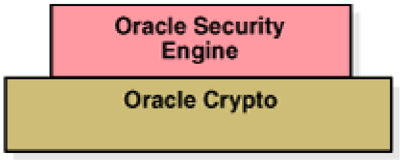
Oracle CMS provides tools for reading and writing CMS objects, as well as the foundation for the Oracle S/MIME tools for e-mail security, including certificate parsing and verification, X.509 certificates, private key encryption, and related features.



This graphic shows that Oracle's S/MIME tool is built on Oracle CMS.

Tools for Low-level Cryptographic Applications

Oracle Crypto provides a broad range of cryptographic algorithms, message digests, and MAC algorithms, as well as the basis for the Oracle Security Engine for X.509 certificates and CRL extensions.



This graphic shows that Oracle's Security Engine tool is built upon Oracle Crypto.

1.6.2 Supported Standards

The Oracle Security Developer Tools support the standards and protocols defined in

Table 1–2 Supported Standards

Feature/Component	Standard
SAML	- SAML 1.0 - SAML 1.1 - SAML 2.0
XML Security Transforms	The following transforms are supported: - canonicalization 1.0 - canonicalization 1.1 - exclusive canonicalization - decrypt transform - xpath filter transform - xpath filter 2.0 transform - enveloped signature transform
WS-Security	WS-Security 1.1, including: - WS-Security Core Specification 1.1 - Username Token Profile 1.1 - X.509 Token Profile 1.1 - SAML Token profile 1.1 - Kerberos Token Profile 1.1 - SOAP with Attachments (SWA) Profile 1.1
XKMS	
S/MIME	

> **Note:** By way of clarification, note that SAML token profile 1.1 applies to SAML 2.0, while SAML token profile 1.0 applies to SAML 1.0 and SAML 1.1.

1.6.3 Oracle Crypto

The Oracle Crypto toolkit provides the following features:

- Public key cryptography algorithms such as **RSA**
- Digital signature algorithms such as Digital Signature Algorithm (DSA) and **RSA**
- Key exchange algorithms such as **Diffie-Hellman**
- Symmetric cryptography algorithms such as **Blowfish**, **AES**, **DES**, **3DES**, **RC2**, and **RC4**
- Message digest algorithms such as **MD2**, **MD4**, **MD5**, **SHA**-1, **SHA**-256, **SHA**-384, and **SHA**-512
- **MAC** algorithms such as **HMAC**-MD5 and **HMAC**-SHA-1
- Methods for building and parsing **ASN.1** objects

1.6.4 Oracle Security Engine

The Oracle Security Engine toolkit provides the following features:

- **X.509** Version 3 Certificates, as defined in RFC 3280
- Full **PKCS#12** support
- **PKCS#10** support for certificate requests
- **CRL**s as defined in RFC 3280
- Implementation of **Signed Public Key And Challenge (SPKAC)**
- Support for **X.500** Relative Distinguished Name
- **PKCS#7** support for wrapping X.509 certificates and CRLs
- Implementation of standard X.509 certificates and CRL extensions

1.6.5 Oracle CMS

Oracle CMS provides an extensive set of tools for reading and writing CMS objects, and supporting tools for developing secure message envelopes.

Oracle CMS implements the IETF Cryptographic Message Syntax specified in RFC-2630. Oracle CMS implements all the RFC-2630 content types.

1.6.6 Oracle S/MIME

Oracle S/MIME provides the following **Secure/Multipurpose Internet Mail Extension (S/MIME)** features:

- Full support for **X.509** Version 3 certificates with extensions, including certificate parsing and verification
- Support for X.509 certificate chains in **PKCS#7** and **PKCS#12** formats
- Private key encryption using **PKCS#5**, **PKCS#8**, and **PKCS#12**
- An integrated **ASN.1** library for input and output of data in ASN.1 **DER**/**BER** format

1.6.7 Oracle PKI SDK

Oracle PKI SDK contains a set of tools for working with **digital certificate**s, including access to LDAP directories, date stamping of digital messages, certificate validation, and certificate management. It includes the following toolkits:

- Oracle PKI LDAP SDK
- Oracle PKI TSP SDK
- Oracle PKI OCSP SDK
- Oracle PKI CMP SDK

1.6.7.1 Oracle PKI LDAP SDK

Oracle PKI LDAP SDK provides facilities for accessing a digital certificate within an LDAP directory. Some of the tasks you can perform using the Oracle PKI LDAP SDK are:

- Validating a user’s certificate in an LDAP directory
- Adding a certificate to an LDAP directory
- Retrieving a certificate from an LDAP directory
- Deleting a certificate from an LDAP directory

1.6.7.2 Oracle PKI TSP SDK

The Oracle PKI TSP SDK provides the following features and functionality:

- Oracle PKI TSP SDK conforms to RFC 3161 and is compatible with other products that conform to this time stamp protocol (TSP) specification.
- Oracle PKI TSP SDK provides an example implementation of a TSA server to use for testing TSP request messages, or as a basis for developing your own time stamping service.

1.6.7.3 Oracle PKI OCSP SDK

The Oracle PKI OCSP SDK provides the following features and functionality:

- The Oracle PKI OCSP SDK conforms to RFC 2560 and is compatible with other products that conform to this specification, such as Valicert's Validation Authority.
- The Oracle PKI OCSP SDK API provides classes and methods for constructing OCSP request messages that can be sent through HTTP to any RFC 2560 compliant validation authority.
- The Oracle PKI OCSP SDK API provides classes and methods for constructing responses to OCSP request messages, and an OCSP server implementation that you can use as a basis for developing your own OCSP server to check the validity of certificates you have issued.

1.6.7.4 Oracle PKI CMP SDK

The set of functions supported by **certificate management protocol (CMP)** messages are:

- Registration of an entity, which takes place prior to issuing a certificate
- Initialization, such as the generation of a key pair
- Certification (issuing certificates)
- Key pair recovery for reissuing lost keys
- Key pair updates when a certificate expires and a new key pair and certificate needs to be generated
- Revocation requests to the CA to include a certificate in a CRL
- Cross-certification between two CAs

The Oracle PKI CMP SDK conforms to RFC 2510 and is compatible with other products that conform to this certificate management protocol (CMP) specification. In addition, it conforms to RFC 2511 and is compatible with other products that conform to this certificate request message format (CRMF) specification.

1.6.8 Oracle XML Security

XML Security refers to the common data security requirements of **XML** documents, such as confidentiality, integrity, message authentication, and non-repudiation.

Oracle XML Security fulfills these needs by providing the following features:

- Support for the Decryption Transform proposed standard
- Support for the XML Canonicalization standard
- Support for the Exclusive XML Canonicalization standard

- Compatibility with a wide range of JAXP 1.1 compliant XML parsers and XSLT engines

1.6.9 Oracle SAML

The Oracle SAML API provides tools and documentation to assist developers of **SAML**-compliant Java security services. You can integrate Oracle SAML into existing Java solutions, including applets, applications, EJBs, servlets, and JSPs.

Oracle SAML provides the following features:

- Support for the SAML 1.0/1.1 and 2.0 specifications
- Support for SAML-based **single sign-on (SSO)**, Attribute, Metadata, Enhanced Client Proxy, and federated identity profiles

1.6.10 Oracle Web Services Security

Oracle Web Services Security provides an authentication and authorization framework based on Organization for the Advancement of Structured Information Standards (OASIS) specifications. Oracle Web Services Security provides the following features:

- Support for the SOAP Message Security standard (SOAP 1.1, 1.2)
- Support for the Username Token Profile standard (UsernameToken Profile 1.1)
- Support for the X.509 Certificate Token Profile standard
- Support for the WSS SAML Token Profile (version 1.0)

Note: The WSS SAML Token Profile version is different from the SAML version.

1.6.11 Oracle Liberty SDK

Oracle Liberty SDK allows Java developers to design and develop **single sign-on (SSO)** and federated identity solutions based on the **Liberty Alliance** specifications. Oracle Liberty SDK, available in versions 1.1 and 1.2, aims to unify, simplify, and extend all aspects of development and integration of systems conforming to the Liberty Alliance 1.1 and 1.2 specifications.

Oracle Liberty SDK provides the following features:

- Support for the Liberty Alliance Project version 1.1 and 1.2 specifications
- Support for Liberty-based Single Sign-on and Federated Identity

Note: For additional information about the standards and specifications mentioned in this chapter, see Appendix A, "References".

1.6.12 Oracle XKMS

Oracle XKMS (XML Key Management Specification) provides a convenient way to handle public key infrastructures by allowing developers to write XML transactions for digital signature processing. Oracle XKMS implements the W3C XKMS standard and avoids some of the cost and complexity involved with public key infrastructures.

2

Migrating to the JCE Framework

The Oracle Security Developer Tools framework in OracleAS 11gR1 introduces changes to low-level libraries to comply with the Java Cryptography Extension (JCE) framework.

The changes affect both client programs and higher-level libraries of the Oracle Security Developer Tools.

This chapter describes how the changes affect the toolkit architecture , and explain how you can migrate your programs to leverage the new functions. It contains these topics:

- The JCE Framework
- JCE Keys
- JCE Certificates
- JCE Certificate Revocation Lists (CRLs)
- JCE Keystores

Additional Reading

The primary focus of this chapter is on the changes to the Oracle Security Developer Tools for the JCE framework, and how to migrate your existing security artifacts to JCE objects.

For more information about how to utilize the capabilities of the JCE framework and security-related APIs, including such topics as generating different types of keys and key pairs, certificates, and so on, refer to the JDK 6 Security documentation at `http://java.sun.com/javase/6/docs/technotes/guides/security/index.html`.

2.1 The JCE Framework

Prior to Oracle Fusion Middleware 11*g*, Oracle Security Developer Tools used a cryptographic engine that was developed prior to the adoption of JCE in the market. To enable applications (including Oracle Application Server) to continue their move to adopt JCE, the Oracle Security Developer Tools have standardized on low-level libraries that are compliant with the Java Cryptography Extension (JCE) framework with Oracle Fusion Middleware 11*g*. Benefits of the new toolkit include:

- standards-based implementations of cryptographic and certificate management engines
- a pluggable JCE provider architecture that enables you to leverage third-party JCE provider implementations

- the ability to use third-party providers as the cryptographic engine

2.2 JCE Keys

In OracleAS 11*g*R1, the higher level toolkits (Oracle XML Security, Oracle Web Services Security, Oracle CMS, Oracle S/MIME, Oracle XKMS) have changed so that instead of taking Oracle cryptographic keys and certificates, they take standard JCE keys and certificates. Thus, APIs that were taking `oracle.security.crypto.core.PublicKey` now take a `java.security.PublicKey`.

> **Note:** This discussion highlights changes in the Oracle Security Developer Tools in support of JCE. For fuller details of all the available cryptographic functions, see the API documentation.

- `oracle.security.crypto.core.PublicKey` changed to `java.security.PublicKey`
- `oracle.security.crypto.core.PrivateKey` changed to `java.security.PrivateKey`
- `oracle.security.crypto.core.SymmetricKey` changed to `javax.crypto.SecretKey`

2.2.1 Converting an Existing Key Object to a JCE Key Object

If you are using a java.security.KeyStore to store your keys, you will directly get a java.security.PrivateKey object from it, so you do not need to do any conversion.

However if you are using a oracle.security.crypto.cert.PKCS12 object to store your keys, you will get an oracle.security.crypto.core.PrivateKey from it, and then you need to convert to a java.security.PrivateKey object.

Converting a Private Key from Oracle Security Developer Tools to JCE Object

```
//***** Conversion or PrivateKeys from OSDT -> JCE *******
{
// Example code to convert an RSAPrivateKey (non CRT) to JCE
oracle.security.crypto.core.RSAPrivateKey osdtKey = null;
RSAPrivateKeySpec keySpec = new RSAPrivateKeySpec(
osdtKey.getModulus(), osdtKey.getExponent());
KeyFactory kf = KeyFactory.getInstance("RSA");
RSAPrivateKey jceKey = (RSAPrivateKey)kf.generatePrivate(keySpec);
}

{
// Example code to convert an RSAPrivateKey (CRT) to JCE
oracle.security.crypto.core.RSAPrivateKey osdtKey = null;
RSAPrivateKeySpec keySpec = new RSAPrivateCrtKeySpec(
osdtKey.getModulus(),
osdtKey.getPublicExponent(),
osdtKey.getExponent(),
osdtKey.getPrimeP(),
osdtKey.getPrimeQ(),
osdtKey.getPrimeExponentP(),
osdtKey.getPrimeExponentQ(),
osdtKey.getCrtCoefficient());
KeyFactory kf = KeyFactory.getInstance("RSA");
RSAPrivateCrtKey jceKey = (RSAPrivateCrtKey)kf.generatePrivate(keySpec);

}

{
// Example code to convert a DSAPrivateKey to JCE
oracle.security.crypto.core.DSAPrivateKey osdtKey = null;
DSAPrivateKeySpec keySpec = new DSAPrivateKeySpec(
osdtKey.getX(),
osdtKey.getParams().getP(),
osdtKey.getParams().getQ(),
osdtKey.getParams().getG());

KeyFactory kf = KeyFactory.getInstance("DSA");
DSAPrivateKey jceKey = (DSAPrivateKey)kf.generatePrivate(keySpec);

}

{
// Example code to convert a DHPrivateKey to JCE
oracle.security.crypto.core.DHPrivateKey osdtKey = null;

// Note q is assumed to be (p-1)/2
DHPrivateKeySpec keySpec = new DHPrivateKeySpec(
osdtKey.getX(),
osdtKey.getParams().getP(),
osdtKey.getParams().getG());

KeyFactory kf = KeyFactory.getInstance("DiffieHelman");
DHPrivateKey jceKey = (DHPrivateKey)kf.generatePrivate(keySpec);

}
```

Converting a Private Key from JCE Object to Oracle Security Developer Tools

```
//***** Conversion or Private Keys from JCE -> OSDT *******
{
// Example code to convert an RSAPrivateKey (non CRT) to OSDT
RSAPrivateKey jceKey = null;
oracle.security.crypto.core.RSAPrivateKey osdtKey =
new oracle.security.crypto.core.RSAPrivateKey(
jceKey.getModulus(),
jceKey.getPrivateExponent());
}

{
// Example code to convert an RSAPrivateKey (CRT) to OSDT
RSAPrivateCrtKey jceKey = null;
oracle.security.crypto.core.RSAPrivateKey osdtKey =
new oracle.security.crypto.core.RSAPrivateKey(
jceKey.getModulus(),
jceKey.getPrivateExponent(),
jceKey.getPublicExponent(),
jceKey.getPrimeP(),
jceKey.getPrimeQ(),
jceKey.getPrimeExponentP(),
jceKey.getPrimeExponentQ(),
jceKey.getCrtCoefficient());
}
```

```
{
// Example code to convert an DSAPrivateKey to OSDT
DSAPrivateKey jceKey = null;
oracle.security.crypto.core.DSAPrivateKey osdtKey =
new oracle.security.crypto.core.DSAPrivateKey(
jceKey.getX(),
new oracle.security.crypto.core.DSAParams(
jceKey.getParams().getP(),
jceKey.getParams().getQ(),
jceKey.getParams().getG()));
}

{
// Example code to convert an DHPrivateKey to OSDT
DHPrivateKey jceKey = null;

// Note calculate q = (p-1)/2
oracle.security.crypto.core.DHPrivateKey osdtKey =
new oracle.security.crypto.core.DHPrivateKey(
jceKey.getX(),
new oracle.security.crypto.core.DHParams(
jceKey.getParams().getP(),
jceKey.getParams().getG(),
jceKey.getParams().getP().subtract(new BigInteger("1")).divide(new
BigInteger("2"))));
}
```

2.3 JCE Certificates

In OracleAS 11*g*R1, `oracle.security.crypto.cert.X509` is changed to `java.security.cert.X509Certificate`.

Several utility methods are available for creating and working with JCE certificates:

2.3.1 Switching to a JCE Certificate

An X509Certificate object can be created from an input stream using java.security.cert.CertificateFactory. The input stream can be one of the following:

- a FileInputSream, if the certificate is stored in a file, or
- a ByteArrayInputStream, if we got the encoded bytes from an old X509 object, or
- any other sources.

For example, the following code converts an Oracle Security Developer Tools certificate to a JCE certificate:

```
CertificateFactory cf = CertificateFactory.getInstance("X.509");

X509Certificate cert = (X509Certificate)cf.generateCertificate(
    new FileInputStream(certFileName);
```

where `certFileName` is the name of the certificate file.

2.4 JCE Certificate Revocation Lists (CRLs)

In OracleAS 11*g*R1, `oracle.security.crypto.cert.CRL` is replaced by `java.security.cert.CRL`.

You can create the `java.security.cert.CRL` object:

- from an input stream
- by using `java.security.cert.CertificateFactory`

The input stream can be one of the following:

- `FileInputSream`, if the CRL is stored in a file
- `ByteArrayInputStream`, if the encoded bytes were obtained from an old `oracle.security.crypto.cert.CRL` object
- any other source

Here is an example of a CRL object creation:

```
CertificateFactory cf = CertificateFactory.getInstance("X.509");

509Certificate cert = (X509Certificate)cf.generateCRL(
   new FileInputStream(crlFileName));
```

where the `crlFileName` is the name of the CRL file.

2.5 JCE Keystores

Oracle Security Developer Tools provide four types of keystore:

1. the JKS keystore, which is Sun Microsystem's implementation of the java.security.KeyStore interface
2. the Oracle wallet, which is Oracle's implementation of the java.security.KeyStore interface
3. the PKCS12 wallet, which is a proprietary Oracle interface/implementation of PKCS12
4. the PKCS8 wallet, which is a proprietary Oracle interface/implementation of PKCS8

2.5.1 Working with standard KeyStore-type Wallets

You can instantiate a Keystore object using either a Sun Microsystems provider or an Oracle provider depending on the keystore format.

Sun Microsystems Keystore

This example instantiates a JKS keystore for the Sun Microsystems provider:

```
java.security.KeyStore keystore = KeyStore.getInstance("JKS", "SUN");
```

Oracle Keystore

This example instantiates a PKCS12 wallet for the Oracle provider:

```
java.security.KeyStore keystore = KeyStore.getInstance("PKCS12", "OraclePKI");
```

Loading a Keystore File

You perform this task with the `keystore.load` method:

```
keystore.load(new FileInputStream(walletFile), pass);
```

Certificate Retrieval

To retrieve a certificate and private key using an alias:

```
Key key = keystore.getKey(alias);

Certificate cert = keystore.getCert(alias);
```

If the alias is not known in advance, you can list all aliases by calling:

```
keystore.aliases();
```

2.5.2 Working with PKCS12 and PKCS8 Wallets

If you maintain keystores in the PKCS12 or PKCS8 oracle wallet format, you can retrieve keys, certificates or CRLs from those stores in Oracle Security Developer Tools format.

Key Retrieval

In Oracle wallets, the key is found in oracle.security.crypto.core.PrivateKey.

After retrieval, you can convert the keys into the JCE key format, using the utility class PhaosJCEKeyTranslator.

For more information, see Section 2.2.1, "Converting an Existing Key Object to a JCE Key Object".

Certificate Retrieval

In Oracle wallets, the certificate is found in oracle.security.crypto.cert.X509.

After retrieval, you can:

1. get the encoded value of the X509 certificate, for example X509.getEncoded();
2. use the CertificateFactory to create a X509Certificate instance, based on the encoded bytes value.

For more information, see . Section 2.3, "JCE Certificates".

CRL Retrieval

In Oracle wallets, the CRL is found in oracle.security.crypto.cert.CRL.

After retrieval, you can:

1. get the encoded value of the CRL, for example CRL.getEncoded();
2. use the CertificateFactory to create a java.security.cert.CRL instance, based on the encoded bytes value.

For more information, see . Section 2.4, "JCE Certificate Revocation Lists (CRLs)".

3 Oracle Crypto

This chapter provides information about using the Oracle Crypto Software Development Kit (SDK). Oracle Crypto allows Java developers to create applications that ensure data security and integrity.

Note: The use of the Oracle Crypto library is not recommended beginning with Oracle AS 11gR1. Instead, use the standard JCE interface for all cryptographic operations.

However, for ASN.1 parsing you should continue to use the Oracle Crypto library, as there are no standard APIs in the JDKs for that task.

For more information, see these resources:

- JDK documentation on using the JCE interfaces at `http://java.sun.com/javase/6/docs/technotes/guides/security/crypto/CryptoSpec.html`
- Chapter 2, "Migrating to the JCE Framework"

This chapter contains the following topics:

- Oracle Crypto Features and Benefits
- Setting Up Your Oracle Crypto Environment
- Core Classes and Interfaces
- The Oracle Crypto Java API Reference
- Example Programs

3.1 Oracle Crypto Features and Benefits

Oracle Crypto provides the following features:

- Public key cryptography algorithms such as **RSA**
- Digital signature algorithms such as **DSA** and **RSA**
- Key exchange algorithms such as **Diffie-Hellman**
- Symmetric cryptography algorithms such as **Blowfish**, **AES**, **DES**, **3DES**, **RC2**, and **RC4**
- Message digest algorithms such as **MD2**, **MD4**, **MD5**, **SHA**-1, **SHA**-256, **SHA**-384, and **SHA**-512
- **MAC** algorithms such as **HMAC**-MD5 and **HMAC**-SHA-1

- Methods for building and parsing **ASN.1** objects

3.1.1 Oracle Crypto Packages

Oracle Crypto contains the following packages:

- `oracle.security.crypto.core` - Basic cryptographic primitives
- `oracle.security.crypto.core.math` - Utility classes for handling mathematical functions
- `oracle.security.crypto.util` - Various utility classes
- `oracle.security.crypto.asn1` - Facilities for reading and writing both BER-encoded and DER-encoded ASN.1 structures

3.2 Setting Up Your Oracle Crypto Environment

This section explains how to set up your environment to use Oracle Crypto. It contains the following topics:

- System Requirements for Oracle Crypto
- Setting the CLASSPATH Environment Variable

3.2.1 System Requirements for Oracle Crypto

In order to use the Oracle Crypto SDK, your system must have the Java Development Kit (JDK) version 1.5 or higher.

3.2.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to the required jar and class files. Make sure that the `osdt_core.jar` file is included in your `CLASSPATH`.

3.2.2.1 Setting the CLASSPATH on Windows

To set your `CLASSPATH` on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click Edit.
5. Add the full path and file names for all of the required jar and class files to the `CLASSPATH`.

   For example, your `CLASSPATH` might look like this:

   ```
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar
   ```

6. Click **OK**.

3.2.2.2 Setting the CLASSPATH on UNIX

On UNIX, set your `CLASSPATH` environment variable to include the full path and file name of all of the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar
```

3.3 Core Classes and Interfaces

This section provides information and code samples for using the core classes and interfaces of Oracle Crypto. The core classes and interfaces are divided into the following categories:

- Keys
- Key Generation
- Ciphers
- Signatures
- Message Digests
- Key Agreement
- Pseudo-Random Number Generators

3.3.1 Keys

Oracle Crypto provides the following classes and interfaces for working with keys:

- The oracle.security.crypto.core.Key Interface
- The oracle.security.crypto.core.PrivateKey Interface
- The oracle.security.crypto.core.PublicKey Interface
- The oracle.security.crypto.core.SymmetricKey Class

3.3.1.1 The oracle.security.crypto.core.Key Interface

This interface represents a key which may be used for encryption or decryption, for generating or verifying a digital signature, or for generating or verifying a MAC. A key may be a private key, a public key, or a symmetric key.

3.3.1.2 The oracle.security.crypto.core.PrivateKey Interface

This interface represents a private key which may be an `RSAPrivateKey`, a `DSAPrivateKey`, a `DHPrivateKey`, an `ECPrivateKey` or a `PrivateKeyPKCS8` instance that holds an encrypted private key.

3.3.1.3 The oracle.security.crypto.core.PublicKey Interface

This interface represents a public key which may be a `RSAPublicKey`, a `DSAPublicKey`, a `DHPublicKey` or a `ECPublicKey` instance.

3.3.1.4 The oracle.security.crypto.core.SymmetricKey Class

This class represents a symmetric key which may be used for encryption, decryption or for MAC operations.

3.3.2 Key Generation

Oracle Crypto provides the following classes for key generation:

- The oracle.security.crypto.core.KeyPairGenerator Class
- The oracle.security.crypto.core.SymmetricKeyGenerator Class

3.3.2.1 The oracle.security.crypto.core.KeyPairGenerator Class

This abstract class is used to generate key pairs such as RSA, DSA, Diffie-Hellman or ECDSA key pairs.

To get a new key pair generator, create a new instance of `KeyPairGenerator` by calling the static `getInstance()` method with an `AlgorithmIdentifier` object as a parameter. Example 3–1 shows how to create a new `KeyPairGenerator` instance:

Example 3–1 Code Example for Creating a New `KeyPairGenerator` ***Instance***

```
KeyPairGenerator kpg = KeyPairGenerator.getInstance(AlgID.rsaEncryption);
```

This creates a `KeyPairGenerator` object from one of the concrete classes: `RSAKeyPairGenerator`, `DSAKeyPairGenerator`, `DHKeyPairGenerator`, or `ECKeyPairGenerator`.

Initialize the key pair generator by using one of the `initialize()` methods. Generate the key pair with the `generateKeyPair()` method. Example 3–2 shows how to initialize the key pair generator and then generate a key pair:

Example 3–2 Code Example for Initializing and Generating a Key Pair

```
kpg.initialize(1024, RandomBitsSource.getDefault());
KeyPair kp = kpg.generateKeyPair();
PrivateKey privKey = kp.getPrivate();
PublicKey pubKey = kp.getPublic();
```

Save the keys using the `output()` method, or in the case of the private key, encrypt it and save it using the `PrivateKeyPKCS8` class. Example 3–3 shows how to save a key pair.

Example 3–3 Code Example for Saving a Key Pair

```
FileOutputStream pubKeyFos = new
FileOutputStream("my-pub-key.der");
pubKey.output(pubKeyFos);
pubKeyFos.close();

PrivateKeyPKCS8 privKeyPKCS8 =
    new PrivateKeyPKCS8(privKey, "myPassword");
FileOutputStream privKeyFos =
    new FileOutputStream("my-encrypted-priv-key.der");
privKeyPKCS8.output(privKeyFos);
privKeyFos.close();
```

3.3.2.2 The oracle.security.crypto.core.SymmetricKeyGenerator Class

This class generates symmetric key pairs such as Blowfish, DES, 3DES, RC4, RC2, AES, and HMAC keys.

To get a new symmetric key generator, create a new instance of `SymmetricKeyGenerator` by calling the static `getInstance()` method with an `AlgorithmIdentifier` object as a parameter. Example 3–4 shows how to create a new `SymmetricKeyGenerator` instance:

Example 3–4 Code Example for Creating a New `SymmetricKeyGenerator` ***Instance***

```
SymmetricKeyGenerator skg = SymmetricKeyGenerator.getInstance(AlgID.desCBC);
```

Generate the key pair with the `generateKey()` method. You can then save the key by using the `getEncoded()` method. Example 3–5 shows how to generate and save a symmetric key pair.

Example 3–5 Code Example for Generating and Saving Symmetric Keys

```
SymmetricKey sk = skg.generateKey();

FileOutputStream symKeyFos =
    new FileOutputStream("my-sym-key.der");
symKeyFos.write(sk.getEncoded());
symKeyFos.close();
```

3.3.3 Ciphers

The Oracle Crypto Cipher classes and interfaces are divided into the following categories:

- Symmetric Ciphers
- The RSA Cipher
- Password Based Encryption

3.3.3.1 Symmetric Ciphers

The symmetric ciphers are made up of two categories: the block ciphers (such as Blowfish, DES, 3DES, RC2, and AES) and the stream ciphers (such as RC4).

A symmetric cipher can be used for four types of operations:

- Encryption of raw data. Use one of the `encrypt()` methods by passing data to be encrypted.
- Decryption of encrypted data. Use one of the `decrypt()` methods by passing encrypted data to be decrypted.
- Wrapping of private or symmetric keys. Use one of the `wrapKey()` methods by passing the private or symmetric key to be encrypted.
- Unwrapping of private or symmetric encrypted keys. Use either the `unwrapPrivateKey()` or the `unwrapSymmetricKey()` method by passing the encrypted private or symmetric key to be decrypted.

The concrete block cipher classes extend the abstract `oracle.security.crypto.core.BlockCipher` class, which extends the `oracle.security.crypto.core.Cipher` class. The stream cipher classes directly extend the `oracle.security.crypto.core.Cipher` class.

To create a new instance of `Cipher`, call the static `getInstance()` method with an `AlgorithmIdentifier` and a `Key` object as parameters.

Example 3–6 shows how to create a new Cipher instance. First an RC4 object is created and initialized with the specified key. Second a block cipher DES object is created and initialized with the specified key and padding. This creates a cipher and initializes it with the passed parameters. To re-initialize an existing cipher, call one of the `initialize()` methods.

Example 3–6 Code Example for Creating a `Cipher` Instance

```
Cipher rc4 = Cipher.getInstance(AlgID.rc4, rc4SymKey);
Cipher desCipher = Cipher.getInstance(AlgID.desCBC, desSymKey, Padding.PKCS5);
```

When using CBC ciphers, the `AlgorithmIdentifier` object may hold cryptographic parameters such as the initialization vector (IV) or the effective key length for RC2 ciphers. To specify these parameters when creating or initializing block ciphers, build a `CBCAlgorithmIdentifier` object or `RC2AlgorithmIdentifier` object with the cryptographic parameters. Example 3–7 shows how to create and initialize a CBC cipher and a RC2 cipher.

Example 3–7 Code Example for Creating and Initializing CBC Ciphers

```
CBCAlgorithmIdentifier cbcAlgID =
    new CBCAlgorithmIdentifier(AlgID.desCBC, iv);
desCipher.initialize(cbcAlgID, desSymKey, Padding.PKCS5);
RC2AlgorithmIdentifier rc2AlgID =
    new RC2AlgorithmIdentifier(iv, 56);
BlockCipher rc2Cipher =
    (BlockCipher)Cipher.getInstance(rc2AlgID, rc2SymKey, Padding.PKCS5);
```

3.3.3.2 The RSA Cipher

The RSA cipher is an implementation of PKCS#1 v2.0 that supports the RSAES-OAEP and RSAES-PKCS1-v1_5 encryption schemes. According to the specification, RSAES-OAEP is recommended for new applications, and RSAES-PKCS1-v1_5 is included only for compatibility with existing applications and protocols.

The encryption schemes are used to combine RSA encryption and decryption primitives with an encoding method. Encryption and decryption can only be done through the methods `encrypt(byte[])` and `decrypt(byte[])`.

You can use an RSA cipher for four types of operations:

- Encryption of raw data. Use one of the `encrypt()` methods by passing data to be encrypted.
- Decryption of encrypted data. Use one of the `decrypt()` methods by passing encrypted data to be decrypted.
- Wrapping of keys. Use the `wrapKey()` method by passing the key to be encrypted.
- Unwrapping of encrypted keys. Use the `unwrapSymmetricKey()` method by passing the encrypted key to be decrypted.

To create a new instance of `Cipher`, call the static `getInstance()` method with `AlgorithmIdentifier` and `Key` objects as parameters. Example 3–8 demonstrates how to create an `RSApkcs1` object and initialize it with the specified key. The cipher can then be used to encrypt or decrypt data.

Example 3–8 Code Example for Creating and Initializing an RSA Cipher

```
Cipher rsaEnc = Cipher.getInstance(AlgID.rsaEncryption, pubKey);
byte[] encryptedData = rsaEnc.encrypt(data);
Cipher rsaDec = Cipher.getInstance(AlgID..rsaEncryption, privKey);
byte[] decryptedData = rsaDec.decrypt(encryptedData);
```

When using RSA ciphers, the `AlgorithmIdentifier` object may hold cryptographic parameters such as the mask generation function for RSAES-OAEP. To specify these parameters when creating or initializing RSA ciphers, build an `OAEPAlgorithmIdentifier`, or use the default one located in the `oracle.security.crypto.core.AlgID` interface.

3.3.3.3 Password Based Encryption

The abstract `oracle.security.crypto.core.PBE` class provides methods for Password Based Encryption (PBE) operations. The concrete classes extending the PBE are the `PKCS5PBE` and `PKCS12PBE` classes.

You can use a PBE object for four types of operations:

- Encryption of raw data. For example:

  ```
  byte[] encData = pbeEnc.encrypt("myPassword", data);
  ```

- Decryption of encrypted data. For example:

  ```
  byte[] decData = pbeDec.decrypt("myPassword", encData);
  ```

- Wrapping of private or symmetric keys. For example:

  ```
  byte[] encPrivKey = pbeEnc.encryptPrivateKey("myPassword", privKey);
  byte[] encSymKey = pbeEnc.encryptSymmetricKey("myPassword", symKey);
  ```

- Unwrapping of private or symmetric encrypted keys. For example:

  ```
  PrivateKey decPrivKey = pbeDec.decryptPrivateKey("myPassword", encPrivKey);
  SymmetricKey decSymKey = pbeDec.decryptSymmetricKey("myPassword", encSymKey);
  ```

To create a new instance of PBE, call the static `getInstance()` method with a `PBEAlgorithmIdentifier` object as a parameter. For example:

```
PBE pbeEnc = PBE.getInstance(pbeAlgID);
```

This will create a `PKCS5PBE` object and initialize it with the specified PBE algorithm. The PBE can then be used to encrypt or decrypt data, wrap or unwrap keys.

When using PBE objects, the `AlgorithmIdentifier` object may hold cryptographic parameters such as the salt or the iteration count as well as the ASN.1 Object Identifier specifying the PBE algorithm to use. To specify these parameters when creating or initializing PBEs, build a `PBEAlgorithmIdentifier` object with the cryptographic parameters.

Example 3–9 Code Example for Creating a PBE Object

```
PBEAlgorithmIdentifier pbeAlgID =
    new PBEAlgorithmIdentifier(PBEAlgorithmIdentifier.pbeWithMD5AndDES_CBC, salt, 1024);
pbeEnc.initialize(pbeAlgID);
PBE pbeDec = PBE.getInstance(pbeAlgID);
```

3.3.4 Signatures

The `oracle.security.crypto.core.Signature` abstract class provides methods to sign and verify signatures. The concrete classes extending the `Signature` class are the `RSAMDSignature`, `DSA` and the `ECDSA` classes.

The algorithms available for signature operations are:

- For RSA: `AlgID.md2WithRSAEncryption`, `AlgID.md5WithRSAEncryption` and `AlgID.sha_1WithRSAEncryption`
- For DSA: `AlgID.dsaWithSHA1`
- For ECDSA: `AlgID.ecdsaWithSHA1`

To create a new instance of `Signature`, call the static `getInstance()` method with an `AlgorithmIdentifier` and a `PrivateKey` or `PublicKey` objects as parameters. Example 3–10 shows how to create a new `Signature` object and initialize it with the specified algorithm.

Example 3–10 Code Example for Creating a New `Signature` ***Object***

```
Signature rsaSign = Signature.getInstance(AlgID.md5WithRSAEncryption);
Signature rsaVerif = Signature.getInstance(AlgID.md5WithRSAEncryption);
```

Example 3–11 shows how to set the keys for the `Signature` objects and set the document to be signed or verified.

Example 3–11 Code Example for Setting Signature Keys and Documents

```
rsaSign.setPrivateKey(privKey);
rsaSign.setDocument(data);
rsaVerif.setPublicKey(pubKey);
rsaVerif.setDocument(data);
```

Example 3–12 shows how to compute the signature using the private key or to verify the signature using the public key and the signature bytes.

Example 3–12 Code Example for Computing or Verifying a Signature

```
byte[] sigBytes = rsaSign.sign();
boolean verified = rsaVerif.verify(sigBytes);
```

3.3.5 Message Digests

Oracle Crypto provides the following message digest classes:

- The oracle.security.crypto.core.MessageDigest Class
- The oracle.security.crypto.core.MAC Class

3.3.5.1 The oracle.security.crypto.core.MessageDigest Class

The `MessageDigest` abstract class provides methods to hash and digest data. The concrete classes extending the `MessageDigest` class are the `MD2`, `MD4`, `MD5` and the `SHA` classes.

The available algorithms for message digest operations are: `AlgID.md2`, `AlgID.md4`, `AlgID.md5`, `AlgID.sha_1`, `AlgID.sha_256`, `AlgID.sha_384` and `AlgID.sha_512`.

The basic process for creating a message digest is as follows:

1. Create a new instance of `MessageDigest` by calling the static `getInstance()` method with an `AlgorithmIdentifier` object as a parameter.
2. Add the data to be digested.
3. Compute the hash value.

Example 3–13 shows how to create an MD5 message digest object.

Example 3–13 Code Example for Creating a Message Digest

```
//Create a new MD5 MessageDigest object
MessageDigest md5 = Signature.getInstance(AlgID.md5);
```

```
//Add the data to be digested
md5.udpate(data1);
md5.udpate(data2);

//Compute the hash value
md5.computeCurrent();
byte[] digestBits = md5.getDigestBits();
```

3.3.5.2 The oracle.security.crypto.core.MAC Class

The `MAC` abstract class provides methods to compute and verify a Message Authentication Code (MAC). The concrete class extending the `MAC` is the `HMAC` class.

The available algorithms for MAC operations are: `AlgID.hmacMD5` and `AlgID.hmacSHA`.

The basic process for creating a MAC is as follows:

1. Create a new instance of `MAC` by calling the static `getInstance()` method with an `AlgorithmIdentifier` and a `SymmetricKey` object as a parameter.
2. Add the data to be digested.
3. Compute the MAC value and verify it.

Example 3–14 shows how to create a new HMAC object with the HMAC-SHA1 algorithm.

Example 3–14 Code Example for Creating a MAC

```
//Create an HMAC object with the HMAC-SHA1 algorithm
MAC hmacSha1Compute = MAC.getInstance(AlgID.hmacSHA, hmacSha1Key);

//Add the data to be digested
hmacSha1Compute.udpate(data);

//Compute the MAC value and verify
byte[] macValue = hmacSha1Compute.computeMAC();
boolean verified = hmacSha1Verify.verifyMAC(data, macValue);
```

3.3.6 Key Agreement

The `oracle.security.crypto.core.KeyAgreement` class abstract class provides methods for public key agreement schemes such as Diffie-Hellman. The concrete classes extending the `KeyAgreement` class are the `DHKeyAgreement` and the `ECDHKeyAgreement` classes.

The available algorithms for key agreement operations are: `AlgID.dhKeyAgreement` and `ECDHKeyAgreement` (Elliptic Curve Diffie-Hellman key agreement).

The basic process for key agreement is as follows:

1. Create a new instance of `KeyAgreement` by calling the static `getInstance()` method with an `AlgorithmIdentifier` object as a parameter.
2. Set the local private key and the other party's public key.
3. Compute the shared secret value.

Example 3–15 shows how to perform key agreement.

Example 3–15 Code Example for Key Agreement

```
//Create a DH key agreement object
KeyAgreement dh = KeyAgreement.getInstance(AlgID.dhKeyAgreement);

//Set the private key and public key
dh.setPrivateKey(privKey);
dh.setPublicKey(otherPubKey);

//Compute the shared secret
byte[] sharedSecret = dh.generateSecret();
```

3.3.7 Pseudo-Random Number Generators

In cryptography, random numbers are used to generate keys. Cryptographic systems need cryptographically strong (pseudo) random numbers that cannot be guessed by an attacker.

Oracle Crypto provides the following pseudo-random number generator (PRNG) classes:

- The oracle.security.crypto.core.RandomBitsSource class
- The oracle.security.crypto.core.EntropySource class

3.3.7.1 The oracle.security.crypto.core.RandomBitsSource class

RandomBitsSource is an abstract class representing secure PRNG implementations. Note that, by the very nature of PRNGs, the security of their output depends on the amount and quality of seeding entropy used. Implementing classes should provide guidance as to their proper initialization and use. The concrete classes extending the RandomBitsSource are the MD5RandomBitsSource, SHA1RandomBitsSource, and the DSARandomBitsSource classes.

Create a new instance of RandomBitsSource by calling the static getDefault() method to return the default PRNG:

```
RandomBitsSource rbs = RandomBitsSource.getDefault();
```

A RandomBitsSource object can also be created by instantiating one of the subclasses:

```
RandomBitsSource rbs = new SHA1RandomBitsSource();
```

By default, a newly created PRNG created from a subclass will be seeded. To seed a generic RandomBitsSource object, use one of the seed methods by using a byte array or an EntropySource object:

```
rbs.seed(myByteArray);
```

The object is then ready to generate random data:

```
rbs.randomBytes(myRandomByteArray);
```

3.3.7.2 The oracle.security.crypto.core.EntropySource class

The EntropySource class provides a source of seed material for the PRNGs. The concrete classes extending the EntropySource are the SpinnerEntropySource and SREntropySource classes.

Create a new instance of `EntropySource` by calling the static `getDefault()` method to return the default entropy source:

```
EntropySource es = EntropySource.getDefault();
```

You can also create an `EntropySource` object by instantiating one of the subclasses:

```
EntropySource rbs = new SpinnerEntropySource();
```

The entropy source is readied for use by using one of the `generateByte` methods:

```
es.generateBytes(mySeedingArray);
```

3.4 The Oracle Crypto Java API Reference

The Oracle Crypto Java API reference (Javadoc) is available at:

Oracle Fusion Middleware Crypto Java API Reference for Oracle Security Developer Tools

3.5 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at `http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html`.

4 Oracle Security Engine

This chapter provides information about using the Oracle Security Engine Software Development Kit (SDK) certificate package. Oracle Security Engine is a superset of Oracle Crypto. It contains all of the libraries and tools provided with Oracle Crypto, plus additional packages and utilities for generating digital certificates.

> **Note:** The use of the Oracle Security Engine library is not recommended beginning with Oracle AS 11gR1. Instead use the JDK's Certificate APIs.
>
> For details, see the JDK documentation at:
>
> `http://java.sun.com/javase/6/docs/technotes/guides/security/cert3.html`
>
> However, the following Public-Key Cryptography Standards (PKCS) have no JCE equivalents:
>
> - PKCS#7
> - PKCS#10
> - Signed Public Key And Challenge (SPKAC)
>
> and you can continue using Oracle Security Engine for these features.

Oracle Crypto allows Java developers to develop applications that ensure data security and integrity. For more information about the Oracle Crypto functionality, see "Oracle Crypto" in Chapter 3.

For an overview of public key infrastructure, see "Public Key Infrastructure (PKI)" in Chapter 1.

This chapter contains the following topics:

- Oracle Security Engine Features and Benefits
- Setting Up Your Oracle Security Engine Environment
- Core Classes and Interfaces
- The Oracle Security Engine Java API Reference
- Example Programs

4.1 Oracle Security Engine Features and Benefits

Oracle Security Engine provides the following features:

- **X.509** Version 3 Certificates, as defined in RFC 3280
- Full **PKCS#12** support
- **PKCS#10** support for certificate requests
- **certificate revocation list (CRL)** functionality as defined in RFC 3280
- Implementation of **Signed Public Key And Challenge (SPKAC)**
- Support for **X.500** Relative Distinguished Names
- **PKCS#7** support for wrapping X.509 certificates and CRLs
- Implementation of standard X.509 certificates and CRL extensions

4.1.1 Oracle Security Engine Packages

The Oracle Security Engine toolkit contains the following packages:

- `oracle.security.crypto.cert` - Facilities for handling digital certificates, CRLs, and PKCS#12.
- `oracle.security.crypto.cert.ext` - Standard X.509 certificates and CRL extensions.

4.2 Setting Up Your Oracle Security Engine Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME`. This section provides information for setting up your environment for Oracle Security Engine. It contains the following topics:

- System Requirements for Oracle Security Engine
- Setting the CLASSPATH Environment Variable

4.2.1 System Requirements for Oracle Security Engine

In order to use Oracle Security Engine, your system must have the Java Development Kit (JDK) version 1.4.

4.2.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to the required jar and class files. Make sure the following items are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`

4.2.2.1 Setting the CLASSPATH on Windows

To set your `CLASSPATH` on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click Edit.

5. Add the full path and file names for all of the required jar and class files to the CLASSPATH.

   For example, your CLASSPATH might look like this:

   ```
   %CLASSPATH%;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
   ```

6. Click OK.

4.2.2.2 Setting the CLASSPATH on UNIX

To set your CLASSPATH on UNIX, set your CLASSPATH environment variable to include the full path and file name of all of the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
```

4.3 Core Classes and Interfaces

This section provides information and code samples for using the certificate facility classes of Oracle Security Engine. Oracle Security Engine also includes all of the classes provided with Oracle Crypto. See Chapter 3, "Oracle Crypto" for an overview of the core Oracle Crypto classes.

Class Changes in OracleAS 11*g*R1

In OracleAS 11*g*R1, the oracle.security.crypto.cert.X509 class for certificate management has been replaced with java.security.cert.X509Certificate

The Core Certificate Classes

The core certificate facility classes are:

- The oracle.security.crypto.cert.X500RDN Class
- The oracle.security.crypto.cert.X500Name Class
- The oracle.security.crypto.cert.CertificateRequest Class
- The java.security.cert.X509Certificate Class

4.3.1 The oracle.security.crypto.cert.X500RDN Class

This class represents an X.500 Relative Distinguished Name (RDN). This is the building block for X.500 names. A RDN consists of a set of attribute-value pairs. Typically, there is a single attribute-value pair in each RDN.

Example 4–1 Code Example for Creating and Retrieving an* `X500RDN` *Object

```
// Create the X500RDN object
X500RDN rdn = new X500RDN(PKIX.id_at_commonName, "Joe Smith");

// Retrieve the value
X500Name n = Instance of oracle.security.crypto.cert.X500Name;
String name = n.getAttribute(PKIX.id_at_commonName).getValue().getValue();
```

4.3.2 The oracle.security.crypto.cert.X500Name Class

This class represents distinguished names as used in the X.500 series of specifications, defined in X.520. An `X500Name` object is made of `X500RDN` objects. An X500Name holds attributes defining an entity such as the common name, country, organization, and so on.

To create an `X500Name` object, use the standard constructor and then populate the object with attributes. Once created, the object can then be DER-encoded to make it available to other processes:

Example 4–2 Code Example for Creating an X500Name Object

```
X500Name name = new X500Name();
name.addComponent(PKIX.id_at_commonName, "Joe Smith");
name.addComponent(PKIX.id_at_countryName, "USA");
name.addComponent(PKIX.id_at_stateOrProvinceName, "NY");
name.addComponent(PKIX.id_at_localityName, "New York");
name.addComponent(PKIX.id_at_organizationName, "Oracle");
name.addComponent(PKIX.id_at_organizationalUnitName, "Engineering");
name.addComponent(PKIX.emailAddress, "joe.smith@oracle.com");

// Make object DER-encoded so its available to other processes

byte[] encodedName = Utils.toBytes(name);
X500Name n = new X500Name(new ByteArrayInputStream(encodedName));
String name = n.getAttribute(PKIX.id_at_commonName).getValue().getValue();
String email = n.getAttribute(PKIX.emailAddress).getValue().getValue();
```

4.3.3 The oracle.security.crypto.cert.CertificateRequest Class

This class represents a PKCS#10 certificate request containing information about an entity and a signature of the content of the request. The certificate request is used to convey information and authentication data (the signature) that will be used by a Certificate Authority (CA) to generate a certificate for the corresponding entity.

Creating a new certificate request involves the following high-level steps:

1. Create a new instance of `CertificateRequest` by using the empty constructor and setting the keys and the subject name, or by using the constructor taking an `X500Name` and a `KeyPair` object.
2. Add X.509 extensions to the certificate request.
3. Sign the certificate request and save it to a file.
4. Send the certificate request you created to a Certificate Authority.

Example 4–3 Code Example for Creating a Certificate Request

```
//Create CertificateRequest by setting the keys and subject name
 CertificateRequest certReq = new CertificateRequest();
 certReq.setPrivateKey(privKey);
certReq.setPublicKey(pubKey);
 certReq.setSubject(subjectName);

//OR

// Create CertificateRequest by taking an X500Name and KeyPair object
CertificateRequest certReq = new CertificateRequest(subjectName, keyPair);
```

```
// Add X.509 certificate extensions in a extensionRequest attribute
X509ExtensionSet extSet = new X509ExtensionSet();

// Basic Constraints: non-CA, critical
extSet.addExtension(new BasicConstraintsExtension(false, true));

// Key Usage: signature, data encipherment, key agreement
// & non-repudiation flags, critical
extSet.addExtension(new KeyUsageExtension(new int[] {
     KeyUsageExtension.DIGITAL_SIGNATURE,
     KeyUsageExtension.DATA_ENCIPHERMENT,
     KeyUsageExtension.KEY_AGREEMENT,
     KeyUsageExtension.NON_REPUDIATION},
        true));

// Subject Alternative Name: email address, non-critical
if (email.length() > 0)
    extSet.addExtension(new SubjectAltNameExtension(
        new GeneralName(GeneralName.Type.RFC822_NAME, email), false));

// Subject Key Identifier: key ID bytes, non-critical
extSet.addExtension(new SubjectKeyIDExtension
    (CryptoUtils.generateKeyID(kp.getPublic())));
req.addAttribute(PKIX.extensionRequest, extSet);

// Sign the certificate request and save to file
req.sign();
req.output(reqOS);
reqOS.close();
}
// The certificate request can then be sent to a CA
```

4.3.4 The java.security.cert.X509Certificate Class

Note: This class replaces oracle.security.crypto.cert.X509 for X.509 certificate management in Oracle Application Server 11*g*.

The java.security.cert.X509Certificate class supports the generation of new certificates as well as parsing of existing certificates.

Complete documentation of the java.security.cert.X509Certificate class is available at `http://java.sun.com/j2se/1.4.2/docs/api/java/security/cert/X509Certificate.html`.

Converting Your Code to Use java.security.cert.X509Certificate

You can create the X509Certificate object using the certificate factory java.security.cert.CertificateFactory.

The certificate is generated from an input stream, which can be:

- a FileInputSream, if the certificate is stored in a file, or
- a ByteArrayInputStream, if the encoded bytes are from an existing X509 object, or
- any other source.

An example follows:

```
// Generating an X.509 certificate from a file-based certificate

CertificateFactory cf = CertificateFactory.getInstance("X.509");

X509Certificate cert = (X509Certificate)cf.generateCertificate(
                       new FileInputStream(certFileName);

**
```

4.4 The Oracle Security Engine Java API Reference

The Oracle Security Engine Java API reference (Javadoc) is available at:

Oracle Fusion Middleware Security Engine Java API Reference for Oracle Security Developer Tools

4.5 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at `http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html`.

5 Oracle CMS

This chapter describes key features and benefits of Oracle CMS and explains how to set up and use Oracle CMS.

This chapter contains these topics:

- Oracle CMS Features and Benefits
- Setting Up Your Oracle CMS Environment
- Developing Applications with Oracle CMS
- The Oracle CMS Java API Reference
- Example Programs

5.1 Oracle CMS Features and Benefits

The Oracle CMS SDK is a pure Java API with an extensive set of tools for reading and writing CMS objects, sample programs, and supporting tools for developing secure message envelopes.

Oracle CMS implements the IETF Cryptographic Message Syntax specified in RFC 2630. This syntax is used to digitally sign, digest, authenticate, and encrypt messages.

The Cryptographic Message Syntax is derived from PKCS #7 version 1.5 as specified in RFC 2315 [PKCS#7].

See Also: Appendix A, "References" for a link to the specifications.

5.1.1 Content Types

Oracle CMS supports all the content types specified in RFC-2630, as shown in Table 5–1:

Table 5–1 Content Types Supported by Oracle CMS

Type	Identifier
data	1.2.840.113549.1.7.1
signed-data	1.2.840.113549.1.7.2
enveloped-data	1.2.840.113549.1.7.3
digested-data	1.2.840.113549.1.7.5
encrypted-data	1.2.840.113549.1.7.6
authenticated-data	1.2.840.113549.1.9.16.1.2

Oracle CMS is a full implementation of RFC-2630 with these exceptions:

- There is no support for Attribute Certificates
- There is no support for Key Agreement RecipientInfo

Oracle CMS supports the following Enhanced Security Services for S/MIME content type specified in RFC-2634:

Type	Identifier
receipt	1.2.840.113549.1.9.16.1.2

A link to this document is available in Appendix A, "References".

The following IETF PKIX TimeStamp Protocol content type corresponding to RFC 3161 is supported:

Type	Identifier
TSTInfo	1.2.840.113549.1.9.16.1.4

Note: Oracle CMS will not process a content type other than the ones specified earlier.

5.1.2 Differences Between Oracle CMS Implementation and RFCs

Oracle CMS differs from PKCS #7 v 1.5 [RFC 2315] and IETF CMS [RFC 2630] in the following ways:

- The enveloped-data contains an optional OriginatorInfo.
- In RFC 2630 Enveloped data also contains optional unprotected attributes.
- The SignerIdentifier in the signed-data SignerInfo is a **choice** of IssuerAndSerialNo or SubjectKeyIdentifier.
- In RFC 2630 the Signed Data contains encapsulatedcontentinfo, which contains an optional content, whereas RFC 2315 contains content data.

Note: You must keep these differences in mind if you require interoperability with PKCS#7 implementations.

5.2 Setting Up Your Oracle CMS Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME`. This section describes how to set up your environment for Oracle CMS. It contains the following:

- System Requirements
- Setting the CLASSPATH Environment Variable

5.2.1 System Requirements

In order to use Oracle CMS, your system must have the Java Development Kit (JDK) version 1.5 or higher.

5.2.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your `CLASSPATH`:

- the `osdt_core.jar` file
- the `osdt_cert.jar` file
- the `osdt_cms.jar` file

5.2.2.1 Setting the CLASSPATH on Windows

To set the `CLASSPATH` on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click Edit.
5. Add the full path and file names for all the required jar and class files to the `CLASSPATH`.

   For example, your `CLASSPATH` might look like this:

   ```
   %CLASSPATH%;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cms.jar;
   ```

6. Click OK.

5.2.2.2 Setting the CLASSPATH on UNIX

To set your CLASSPATH on UNIX, set your `CLASSPATH` environment variable to include the full path and file name of all of the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cms.jar
```

5.3 Developing Applications with Oracle CMS

There are two approaches to reading and writing CMS objects with the `oracle.security.crypto.cms` package:

- Using the `CMSContentInfo` classes, which are relatively easy to utilize
- Using one of the following classes:
  - `CMSInputStream`
  - `CMSOutputStream`
  - `CMSInputConnector`
  - `CMSOutputConnector`

These classes provide the ability to read and write CMS objects in a single pass, eliminating the need to accumulate the input data before writing any output.

The Oracle CMS API enables you to build nested (wrapped) CMS objects with no limit on the number of wrappings.

This section contains these topics:

- CMS Object Types
- Constructing CMS Objects using the CMS***ContentInfo Classes
- Constructing CMS Objects using the CMS***Stream and CMS***Connector Classes

5.3.1 CMS Object Types

Application developers should be aware of some specific CMS object types which are discussed in subsequent sections.

A **detached object** applies to data and receipt content types. For these types, a detached object is one where the protected content is absent.

A **degenerate object** is a certificate-only signed-data object and is defined only for the signed-data content type. It refers to the case where the signed-data object has no signers. It is normally used to store certificates and is associated with file extensions `p7b` and `p7c`.

An external signature is defined only for the signed-data content type. It is essentially a detached signed-data object; that is, the signed-data object has one or more signers but the content that was signed is not present in the signed-data object.

5.3.2 Constructing CMS Objects using the CMS***ContentInfo Classes

Table 5–2 lists the classes which make up the CMS***ContentInfo classes.

*Table 5–2 CMS***ContentInfo Classes*

Class	Content Type
CMSDataContentInfo	CMS.id_data
ESSReceipt	CMS.id_ct_receipt (RFC-2634 receipt)
CMSDigestedDataContentInfo	CMS.id_digestedData
CMSSignedDataContentInfo	CMS.id_signedData
CMSEncryptedDataContentInfo	CMS.id_encryptedData
CMSEnvelopedDataContentInfo	CMS.id_envelopedData
CMSAuthenticateDataContentInfo	CMS.id_ct_authData

You can use these classes to:

- Read and write objects of the appropriate content type
- Construct and process detached objects
- Create nested objects

A detailed discussion of `CMS***ContentInfo` classes follows.

5.3.2.1 Abstract Base Class CMSContentInfo

`CMSContentInfo` is an abstract class representing a fundamental CMS object. Table 5–2 lists the subclasses of `CMSContentInfo`.

Some of the useful methods of this abstract class are described in Table 5–3.

Table 5–3 Useful Methods of CMSContentInfo

Method	Description
contentTypeName (oracle.security.crypto.asn1.ASN1ObjectID contentType)	Returns the content type of the object as a string.
getContentType()	Returns the content type of the object as an object identifier (OID).
input(java.io.InputStream is)	Initializes this object by reading a BER encoding from the specified input stream.
inputInstance(java.io.InputStream is)	Creates a new CMSContentInfo object by reading a BER encoding from the specified input stream.
isDegenerate()	Indicates if the object is degenerate.
isDetached()	Indicates if the object is detached.
output(java.io.OutputStream os)	Writes the encoding of the object to the given output stream.

5.3.2.1.1 Constructing a CMS Object

Perform the following steps to construct a CMS object:

1. Create the object of the specified content type.
2. Initialize the object.
3. Call the `output(..)` method to write the object encoding.

If you are reading in an existing `CMSContentInfo`, but you do not know the concrete type in advance, use `inputInstance()`. To create a new object, use one of the constructors of the concrete subclass with which you are working. To read in one of a known concrete type, use the `no-args` constructor and then invoke the `input()` method.

5.3.2.1.2 Reading a CMS Object

Perform the following steps to read an object:

1. Call `CMSContentInfo.inputInstance(..)` to read in the object.
2. Call `getContentType()` to determine its content type.
3. You can now invoke the content type-specific operations.

5.3.2.2 The CMSDataContentInfo Class

The class `CMSDataContentInfo` represents an object of type id-data as defined by the constant CMS.id_data, and is intended to refer to arbitrary octet strings whose interpretation is left up to the application.

A useful method of this class is:

```
byte[] getData()
```

which returns the data stored in the data object.

To create a CMS data object:

1. Create an instance of `CMSDataContentInfo` using the constructor that takes a byte array, documentBytes, that contains the information:

   ```
   CMSDataContentInfo exdata =
       new CMSDataContentInfo(byte[] documentBytes)
   ```

2. Write the data object to a file, for example `data.p7m`:

   ```
   exdata.output(new FileOutputStream("data.p7m"));
   ```

The steps you use when reading a CMS data object depend on whether you know the object's content type.

1. Open a connection to the file using `FileInputStream`.

   If you know that the object stored in the file `data.p7m` is of content type id-data:

   ```
   CMSDataContentInfo exdata =
       new CMSDataContentInfo(new FileInputStream("data.p7m"));
   ```

   However, if you do not know the content type in advance, check the type prior to reading:

   ```
   CMSContentInfo cmsdata =
       CMSContentInfo.inputInstance(new FileInputStream("data.p7m"));
   if (cmsdata instanceof CMSDataContentInfo)
   {
      CMSDataContentInfo exdata =  (CMSDataContentInfo) cmsdata;
      // .....
   }
   ```

2. To access the information stored in the CMS data object:

   ```
   byte[] docBytes = exdata.getData();
   ```

5.3.2.3 The ESSReceipt Class

Class `ESSReceipt` represents an object of type id-ct-receipt as defined by the constant CMS.id_ct_receipt, and refers to an RFC-2634 receipt.

Table 5–4 lists some useful methods of this class.

Table 5–4 Useful Methods of ESSReceipt

Method	Description
byte[] getOriginatorSignatureValue()	Returns the signature value of the message that triggered the generation of this receipt.
ASN1ObjectID getReceiptContentType()	Returns the content type of the message that triggered the generation of this receipt.
byte[] getReceiptData()	Returns the encoded receipt.
byte[] getSignedContentIdentifier()	Returns the signed content identifier of the message that triggered the generation of this receipt.
void inputContent(InputStream is)	Initialize this object by reading the BER encoding from the specified input stream.

Take the following steps to create a CMS receipt object.

1. Create an instance of `ESSReceipt` using the constructor that takes a content type identifier, a byte array containing the signed content identifier and a byte array containing the originator signature value:

   ```
   ESSReceipt rcpt =
       new ESSReceipt(contentType, signedContentIdentifier,
       originatorSignatureValue);
   ```

2. Write the receipt object to a file, for example `data.p7m`:

   ```
   rcpt.output(new FileOutputStream("data.p7m"));
   ```

   > **Note:** When you create an ESSReceipt object, do not leave any input parameters set to `null`.

To read a receipt object:

1. Open a connection to the file using `FileInputStream`.

   If you know that the object stored in the file `data.p7m` is of content type id-ct-receipt:

   ```
   ESSReceipt rcptdata = new ESSReceipt(new FileInputStream("data.p7m"));
   ```

   Otherwise, if the content type is unknown:

   ```
   CMSContentInfo cmsdata =
       CMSContentInfo.inputInstance(new FileInputStream("data.p7m"));
   if (cmsdata instanceof ESSReceipt)
   {
       ESSReceipt rcptdata =  (ESSReceipt) cmsdata;
       // .....
   }
   ```

2. Access the information stored in the receipt object:

   ```
   ASASN1ObjectID contentType = rcptdata.getReceiptContentType();
   byte[] sciBytes = rcptdata.getSignedContentIdentifier()
   byte[] osvBytes = rcptdata.getOriginatorSignatureValue();
   ```

5.3.2.4 The CMSDigestedDataContentInfo Class

The class `CMSDigestedDataContentInfo` represents an object of type id-digestedData as defined by the constant CMS.id_digestedData.

Table 5–5 lists some of the useful methods of this class.

Table 5–5 Useful Methods of `CMSDigestedDataContentInfo`

Method	Description
`byte[] getDigest()`	Returns the message digest value.
`AlgorithmIdentifier getDigestAlgID()`	Returns the message digest algorithm ID.
`CMSContentInfo getEnclosed()`	Returns the digested content.
`ASN1ObjectID getEnclosedContentType()`	Returns the content type of the digested content.
`ASN1Integer getVersion()`	Returns the version number of this object.

Table 5–5 (Cont.) Useful Methods of `CMSDigestedDataContentInfo`

Method	Description
`boolean isDetached()`	Indicates if this object is detached.
`void setEnclosed(CMSContentInfo content)`	Sets the encapsulated content, that is, the object that was originally digested.
`void writeDetached(boolean writeDetached)`	Indicates if the object that is being digested should be omitted when creating the CMSDigestedDataContentInfo object.

5.3.2.4.1 Constructing a CMS Digested-data Object

Take the following steps to create a CMS digested-data object.

1. Create an instance of `CMSDigestedDataContentInfo` using the constructor that takes the object to be digested and the digest algorithm identifier. For example, if contentInfo is a `CMSDataContentInfo` object and MD5 is the digest algorithm:

```
CMSDigestedDataContentInfo dig =
    new CMSDigestedDataContentInfo(contentInfo, CMS.md5);
```

2. Write the CMS digested-data object to a file named `data.p7m`.

```
dig.output(new FileOutputStream("data.p7m"));
```

5.3.2.4.2 Reading a CMS Digested-data Object

The steps you need to read a CMS `digested-data` object depend on whether you know the object's content type.

1. Open a connection to the `data.p7m` file using `FileInputStream`.

   If you know that the object stored in the file is of content type id-digestedData, open the connection as follows:

```
CMSDigestedDataContentInfo digdata =
    new CMSDigestedDataContentInfo(new FileInputStream("data.p7m"));
```

   However, if you do not know the content type in advance, open it as follows:

```
CMSContentInfo cmsdata =
    CMSContentInfo.inputInstance(new FileInputStream("data.p7m"));
if (cmsdata instanceof CMSDigestedDataContentInfo)
{
    CMSDigestedDataContentInfo digdata =
        (CMSDigestedDataContentInfo) cmsdata;
    // .....
}
```

2. To access the information stored in the CMS digested-data object:

```
int version = digdata.getVersionNumber().intValue();
AlgorithmIdentifier digestAlgID = digdata.getDigestAlgID();
byte[] digestValue = digdata.getDigest();
CMSContentInfo digContentInfo = digData.getEnclosed()
if (digData.getEnclosedContentType().equals(CMS.id_data))
    CMSDataContentInfo contentInfo = (CMSDataContentInfo)digContentInfo;
```

3. To verify the integrity of the protected data, verify the digest:

   ```
   digData.verify();
   ```

5.3.2.4.3 Detached digested-data Objects

When working with a detached object, the object that is digested is not a part of the resulting CMS digested-data structure. To generate a detached object, call the `writeDetached (true | false)` method. For example:

```
dig.writeDetached(true);
```

While you can read in a detached CMS digested-data object as shown earlier, the digest verification will fail because the original object that was digested is not present. To resolve this, call the `setEnclosed (CMScontentInfo)` method to set the `digestedContent`:

```
digdata.setEnclosed(CMScontentInfo object);
```

followed by digest verification:

```
digdata.verify();
```

5.3.2.5 The CMSSignedDataContentInfo Class

The class `CMSSignedDataContentInfo` represents an object of type `id-signedData` as defined by the constant `CMS.id_signedData`.

Oracle CMS supports a *choice* of `IssuerAndSerialNo` or `SubjectKeyIdentifier` for use as the `SignerIdentifier`. For interoperability with PKCS #7 and S/MIME, however, the `IssuerAndSerialNo` must be used as the `SignerIdentifier`.

Table 5–6 lists some useful methods of this class:

Table 5–6 Useful Methods of CMSSignedDataContentInfo

Method	Description
void addCertificate(X509Certificate cert)	Appends the given certificate to the list of certificates which will be included with this signed data object.
void addCRL(CRL crl)	Appends the given CRL to the list of CRLs which will be included with this signed data object.
void addSignature(AttributeSet authenticatedAttributes, PrivateKey signerKey, X509Certificate signerCert, AlgorithmIdentifier digestAlgID, AlgorithmIdentifier digestEncryptionAlgID, AttributeSet unauthenticatedAttributes)	Adds a signature using the IssuerAndSerialNumber as the SignerIdentifier, that is, a Version1 CMSSignerInfo.
void addSignature(AttributeSet authenticatedAttributes, PrivateKey signerKey, X509Certificate signerCert, AlgorithmIdentifier digestAlgID, AlgorithmIdentifier digestEncryptionAlgID, AttributeSet unauthenticatedAttributes, boolean useSPKI64)	Adds a signature using the SubjectKeyIdentifier as the SignerIdentifier; that is, a Version3 CMSSignerInfo.
void addSignerInfo(X509Certificate signerCert, CMSSignerInfo signerInfo)	Adds a CMSSignerInfo to the list of signers.

Table 5–6 (Cont.) Useful Methods of CMSSignedDataContentInfo

Method	Description
Vector getCertificates()	Returns the list of certificates included with this signed data object.
Vector getCRLs()	Returns the list of CRLs included with this signed data object.
CMSContentInfo getEnclosed()	Returns the signed document.
ASN1ObjectID getEnclosedContentType()	Returns the content type of the document which was signed.
CMSSignerInfo getSignerInfo(signerCert)	Returns the CMSSignerInfo corresponding to the certificate.
ASN1Integer getVersion()	Returns the version number of this object.
boolean isDegenerate()	IIndicates if this is a degenerate CMSSignedDataContentInfo object (that is, has no SignerInfo structures)
boolean isDetached()	Indicates if this is a detached object.
boolean isExternalSignature()	Checks for the presence of external signatures.
void setEnclosed(CMSContentInfo content)	Sets the content which was signed.
Enumeration signers()	Returns the signatures on this signed data object in the form of an enumeration, each element of which is an instance of `CMSSignerInfo`.
void verify(CertificateTrustPolicy trustPolicy)	Returns normally if this CMS signed data object contains at least one valid signature, according to the given trust policy.
void verify(CertificateTrustPolicy trustPolicy,CMSContentInfo contentInfo)	Returns normally if this signed data object contains at least one valid signature, according to the given trust policy.
void verifySignature(X509Certificate signerCert)	Returns successfully if this signed data object contains a signature which is validated by the given certificate.
void verifySignature(X509Certificate signerCert, CMSContentInfo contentInfo)	Returns successfully if this signed data object contains a signature which is validated by the given certificate and data.
void writeExternalSignature(boolean createExternalSignature)	Indicates if an external signature must be created.

Users of RSA and DSA signature algorithms should note that the providers are pluggable in the Oracle CMS implementation.

5.3.2.5.1 Constructing a CMS Signed-data Object

Follow these steps to create a CMS signed-data object:

1. Create an instance of `CMSSignedDataContentInfo`. For example, to create the `CMSSignedDataContentInfo` object, pass the contentInfo object (the data that is to be signed):

   ```
   CMSSignedDataContentInfo sig =
       new CMSSignedDataContentInfo(contentInfo);
   ```

2. Add signatures:

   ```
   CertificateFactory cf = CertificateFactory.getInstance("X.509");
   X509Certificate envCert =  (X509Certificate)cf.generateCertificate(new
   FileInputStream("name1"));
   PrivateKey signerKey =
       ...;
   ```

   a. To add a signature using the IssuerAndSerialNo as the SignerIdentifier, MD5 digests and RSA Signature Algorithm:

      ```
      sig.addSignature(null, signerKey, signerCert, CMS.md5,
          CMS.rsaEncryption, null);
      ```

   b. To add a signature using the 64 bit SubjectKeyIdentifier as the SignerIdentifier, SHA-1 digests and DSS Signature Algorithm:

      ```
      sig.addSignature(null, signerKey, signerCert, CMS.sha_1,
          CMS.dsaWithSHA, null, true);
      ```

   c. To add a signature using the 160 bit SubjectKeyIdentifier as the SignerIdentifier, SHA-1 digests and RSA Signature Algorithm:

      ```
      sig.addSignature(null, signerKey, signerCert, CMS.sha_1,
          CMS.rsaEncryption, null, false);
      ```

3. Add any Certificates and CRLs:

   ```
   sig.addCertificate (....)
   sig.addCRL (...)
   ```

4. Write the CMS signed-data object to a file, for example `data.p7m`:

   ```
   sig.output(new FileOutputStream("data.p7m"));
   ```

5.3.2.5.2 Reading a CMS Signed-data Object

The steps you need to read a CMS signed-data object depend on whether you know the object's content type.

1. Open a connection to the `data.p7m` file using `FileInputStream`.

   If you know that the object stored in the file is of content type `id-signedData`:

   ```
   CMSSignedDataContentInfo sigdata =
       new CMSSignedDataContentInfo(new FileInputStream("data.p7m"));
   ```

However, if you do not know the content type in advance:

```
CMSContentInfo cmsdata =
    CMSContentInfo.inputInstance(new FileInputStream("data.p7m"));
if (cmsdata instanceof CMSSignedDataContentInfo)
{
    CMSSignedDataContentInfo sigdata =
        (CMSSignedDataContentInfo) cmsdata;
    // .....
}
```

2. Access the information stored in the CMS `signed-data` object:

```
int version = sigdata.getVersion().intValue();
CMSContentInfo sigContentInfo = sigData.getEnclosed()
Vector certs = sigdata.getCertificates();
Vector crls = sigData.getCRLs();
Enumeration e = sigData.signers();
CMSContentInfo sigContentInfo = sigData.getEnclosed();
if (sigData.getEnclosedContentType().equals(CMS.id_data))
    CMSDataContentInfo contentInfo = (CMSDataContentInfo)sigContentInfo;
```

3. Verify the signature using the signer's public key certificate:

```
sigData.verifySignature(signerCert);
```

4. To get more information about the signer:

```
CMSSignerInfo sigInfo = sigdata.getSignerInfo(signerCert);
byte[] signatureValue = sigInfo.getEncryptedDigest();
AlgorithmIdentifier digest = sigInfo.getDigestAlgID();
AlgorithmIdentifier signature = sigInfo.getDigestEncryptionAlgID();
AttributeSet signedAttributes = sigInfo.getAuthenticatedAttributes();
AttributeSet unsignedAttributes = sigInfo.getUnauthenticatedAttributes();
```

5.3.2.5.3 External Signatures (Detached Objects)

For a detached object, the signed object is not part of the resulting CMS signed-data structure. To generate a detached object, call the `writeExternalSignature()` method:

```
sig.writeExternalSignature(true);
```

While you can read in a detached CMS signed-data object as shown in "Reading a CMS Signed-data Object", the signature verification will fail because the original object that was signed is not present. To address this, first call the `setEnclosed (..)` method to set the signed content:

```
sigdata.setEnclosed(contentInfo);
```

followed by signature verification:

```
sigdata.verifySignature(signerCert);
```

5.3.2.5.4 Certificates/CRL-Only Objects

These are essentially `CMSSignedDataContentInfo` objects with attached certificates, or CRLs, or both, but without any signatures. To generate a Certificate/CRL-only object:

```
CMSSignedDataContentInfo sigdata =
    new CMSSignedDataContentInfo(new CMSDataContentInfo(new byte[0]));
sigData.addCertificate (...);
sigData.addCRL( ...);
sigData.output(..);
```

You can read in a Certificate/CRL-only signed-data object as shown in "Reading a CMS Signed-data Object".

5.3.2.6 The CMSEncryptedDataContentInfo Class

The class `CMSEncryptedDataContentInfo` represents an object of type id-encryptedData as defined by the constant CMS.id_encryptedData.

Table 5–7 lists some useful methods of this class.

Table 5–7 Useful Methods of CMSEncryptedDataContentInfo

Method	Description
AlgorithmIdentifier getContentEncryptionAlgID()	Returns the content encryption algorithm
CMSContentInfo getEnclosed(SecreKey decryptionKey)	Returns the decrypted content
ASN1ObjectID getEnclosedContentType()	Returns the content type of the encrypted content
byte[] getEncryptedContent()	Returns the encrypted content
AttributeSet getUnprotectedAttributes()	Returns the set of unprotected attributes
ASN1Integer getVersion()	Returns the version number
boolean isDetached()	Indicates if this is a detached CMS object
void setUnprotectedAttributes (oracle.security.crypto.cert.AttributeSet unprotectedAttributes)	Sets the unprotected attributes
void writeDetached (boolean writeDetachedObject)	Indicates if the encryptedContent will be a part of the EncryptedContentInfo structure in this object's output encoding

Users of encryption operations, including RC2, DES, Triple-DES, AES, and so on, should note that the cipher providers are pluggable in the Oracle Security Engine implementation.

5.3.2.6.1 Constructing a CMS Encrypted-data Object

To create an `encrypted-data` object:

1. Create an instance of `CMSEncryptedDataContentInfo`. For example, if `contentInfo` is a `CMSDataContentInfo` object and the cipher is Triple-DES in CBC mode:

```
SecretKey contentEncryptionKey =
   KeyGenerator.getInstance("DESede").generateKey();
```

```
CMSEncryptedDataContentInfo enc =
   new CMSEncryptedDataContentInfo(contentInfo, contentEncryptionKey,
      CMS.des_ede3_cbc);
```

2. Write the `encrypted-data` object to a file, say `data.p7m`:

```
enc.output(new FileOutputStream("data.p7m"));
```

5.3.2.6.2 Reading a CMS Encrypted-data Object

The steps you need to read an `encrypted-data` object depend on whether you know the object's content type.

1. Open a connection to the `data.p7m` file using `FileInputStream`.

   If you know that the object stored in the file `data.p7m` is of content type id-encryptedData:

```
CMSEncryptedDataContentInfo encdata =
    new CMSEncryptedDataContentInfo(new FileInputStream("data.p7m"));
```

   However, if you do not know the content type in advance:

```
CMSContentInfo cmsdata =
    CMSContentInfo.inputInstance(new FileInputStream("data.p7m"));
if (cmsdata instanceof CMSEncryptedDataContentInfo)
{
    CMSEncryptedDataContentInfo encdata =
        (CMSEncryptedDataContentInfo) cmsdata;
    // .....
}
```

2. To access the information stored in the CMS `encrypted-data` object:

```
int version = encdata.getVersion().intValue();
AlgorithmIdentifier encAlgID = encdata.getContentEncryptionAlgID();
byte[] encValue = encdata.getEncryptedContent();
CMSContentInfo encContentInfo =
    encdata.getEnclosed(ContentEncryptionKey);  //Decrypt the Content
if (encData.getEnclosedContentType().equals(CMS.id_data))
   CMSDataContentInfo contentInfo = (CMSDataContentInfo)encContentInfo;
```

5.3.2.6.3 Detached encrypted-data CMS Objects

If it is a detached object, the encrypted object is not a part of the resulting CMS `encrypted-data` structure. To generate a detached object, call the `writeDetached (..)` method:

```
encData.writeDetached(true);
```

While you can read in a detached CMS encrypted-data object as shown in "Reading a CMS Encrypted-data Object", the content decryption will fail because the original object that was encrypted is not present. Call the `setEnclosed (..)` method to set the encryptedContent:

```
encData.setEnclosed(encryptedcontent());
```

followed by content decryption:

```
encdata.getEnclosed(ContentEncryptionKey);
```

5.3.2.7 The CMSEnvelopedDataContentInfo Class

The class `CMSEnvelopedDataContentInfo` represents an object of type id-envelopedData as defined by the constant CMS.id_envelopedData.

Table 5–8 lists some useful methods of this class:

Table 5–8 Useful Methods of CMSEnvelopedDataContentInfo

Method	Description
void addRecipient(AlgorithmIdentifier keyEncryptionAlgID, SecretKey keyEncryptionKey, byte[] keyIdentifier, Date keyDate, ASN1Sequence otherKeyAttribute)	Adds a recipient using the key encryption (wrap) key exchange mechanism.
void addRecipient(CMSRecipientInfoSpec ris)	Adds a recipient using the key exchange mechanism specification
void addRecipient(X509Certificate recipientCert, AlgorithmIdentifier keyEncryptionAlgID)	Adds a recipient using the key transport (IssuerAndSerialNo) key exchange mechanism
void addRecipient(X509Certificate recipientCert, AlgorithmIdentifier keyEncryptionAlgID, boolean useSPKI64)	Adds a recipient the key transport (SubjectKeyIdentifier) key exchange mechanism
AlgorithmIdentifier getContentEncryptionAlgID()	Returns the content encryption algorithm
CMSContentInfo getEnclosed(PrivateKey privateKey, X509Certificate recipientCert)	Returns the enclosed content after decryption using Key Transport RecipientInfo
CMSContentInfo getEnclosed(SecretKey symmetricKey, byte[] keyIdentifier)	Returns the enclosed content after decryption using Key Encryption RecipientInfo
CMSContentInfo getEnclosed(SecretKey symmetricKey, byte[] keyIdentifier,Date keyDate)	Returns the enclosed content after decryption
ASN1ObjectID getEnclosedContentType()	Returns the content type of the encrypted content
byte[] getEncryptedContent()	Returns the enclosed content which is encrypted
OriginatorInfo getOriginatorInfo()	Returns the OriginatorInfo
AttributeSet getUnprotectedAttribs()	Returns the unprotected attributes
ASN1Integer getVersion()	Returns the version number
boolean isDetached()	Indicates if the encrypted content is not present
Enumeration recipients()	Returns the list of message recipients
void setEnclosed(byte[] encryptedContent)	Sets the Encrypted Content
void setOriginatorInfo(OriginatorInfo origInfo)	Sets the OriginatorInfo
void setUnprotectedAttribs (oracle.security.crypto.cert.AttributeSet unprotectedAttributes)	Sets the unprotected attributes

Table 5–8 (Cont.) Useful Methods of CMSEnvelopedDataContentInfo

Method	Description
void writeDetached(boolean writeDetached)	Indicates if the encrypted content must be omitted from this object's output encoding

5.3.2.7.1 Constructing a CMS Enveloped-data Object

Take these steps to create an `enveloped-data` object:

1. Create an instance of `CMSEnvelopedDataContentInfo`. For example, if contentInfo is a `CMSDataContentInfo` object and the cipher is Triple-DES in CBC mode:

```
CMSEnvelopedDataContentInfo env =
    new CMSEnvelopedDataContentInfo(contentInfo, CMS.des_ede3_cbc);
```

2. Add recipients, keeping in mind the recipient’s key management technique.

   - If the recipient uses the key encryption (wrap) key management mechanism:

   ```
   env.addRecipient(keyEncryptionAlgID, keyEncryptionKey,
       keyIdentifier, keyDate, otherKeyAttribute);
   ```

   - If the recipient key exchange mechanism was specified using a `CMSRecipientInfoSpec` object:

   ```
   env.addRecipient(ris)
   ```

   - If the recipient uses the key transport (`IssuerAndSerialNo` recipient identifier) key management mechanism:

   ```
   env.addRecipient(recipientCert, CMS.rsaEncryption);
   ```

   - If the recipient uses the key transport (64-bit `SubjectKeyIdentifier` recipient identifier) key management mechanism:

   ```
   env.addRecipient(recipientCert, CMS.rsaEncryption, true)
   ```

   - If the recipient uses the key transport (160-bit `SubjectKeyIdentifier` recipient identifier) key management mechanism:

   ```
   env.addRecipient(recipientCert, CMS.rsaEncryption, false)
   ```

3. Set any optional arguments:

```
env.setOriginatorInfo(originatorInfo);
env.setUnprotectedAttribs(unprotectedAttributes);
```

4. Write the CMS `enveloped-data` object to a file, say `data.p7m`:

```
enc.output(new FileOutputStream("data.p7m"));
```

5.3.2.7.2 Reading a CMS Enveloped-data Object

The steps you need to read the object depend on whether you know the object’s content type.

1. Open a connection to the `data.p7m` file using `FileInputStream`. If you know that the object stored in the file is of content type id-envelopedData, open the connection as follows:

   ```
   CMSEnvelopedDataContentInfo envdata =
       new CMSEnvelopedDataContentInfo(new FileInputStream("data.p7m"));
   ```

   However, if you do not know the content type in advance, open it as follows:

   ```
   CMSContentInfo cmsdata =
       CMSContentInfo.inputInstance(new FileInputStream("data.p7m"));
   if (cmsdata instanceof CMSEnvelopedDataContentInfo)
   {
       CMSEnvelopedDataContentInfo envdata =
           (CMSEnvelopedDataContentInfo) cmsdata;
       //
       .....
   }
   ```

2. To access the information stored in the `enveloped-data` object:

   ```
   int version = envdata.getVersion().intValue();
   AlgorithmIdentifier encAlgID = envdata.getContentEncryptionAlgID();
   ASN1ObjectID contentType = envdata.getEnclosedContentType();
   byte[] encryptedContent = envdata.getEncryptedContent();
   OriginatorInfo origInfo = envdata.getOriginatorInfo();
   AttributeSet unprotected = envdata.getUnprotectedAttribs();
   ```

3. Decrypt the content depending on the recipient information:

   ```
   CMSContentInfo envContentInfo =
       env.getEnclosed(privateKey, recipientCert);
   ```

   or

   ```
   CMSContentInfo envContentInfo =
       env.getEnclosed(symmetricKey, keyIdentifier);
   ```

   or

   ```
   CMSContentInfo envContentInfo =
       env.getEnclosed(symmetricKey, keyIdentifier, keyDate)
   if (envContentInfo instanceof CMSDataContentInfo)
   {
       CMSDataContentInfo contentInfo = (CMSDataContentInfo) envContentInfo;
       // ...
   }
   ```

5.3.2.7.3 Key Transport Key Exchange Mechanism

This mechanism supports the use of either `IssuerAndSerialNo` or `SubjectKeyIdentifier` as the recipient identifier.

5.3.2.7.4 Key Agreement Key Exchange Mechanism

This mechanism is not currently supported.

5.3.2.7.5 Key Encryption (Wrap) Key Exchange Mechanism

Oracle CMS supports CMS3DESWrap and CMSRC2Wrap algorithms. Mixed mode wrapping is not supported; for example, 3DES keys cannot be RC2-wrapped.

Note: Using the OtherKeyAttribute could cause interoperability problems.

5.3.2.7.6 Detached Enveloped-data CMS Object

If working with a detached object, note that the enveloped object is not part of the resulting CMS enveloped-data structure. Call the `writeDetached (..)` method to generate a detached object:

```
envdata.writeDetached(true);
```

While you can read in a detached `enveloped-data` object as shown in "Reading a CMS Enveloped-data Object", the content decryption will fail because the original, enveloped object is not present. Call the `setEnclosed (..)` method to set the enveloped content:

```
envdata.setEnclosed(env.getEncryptedContent());
```

followed by content decryption:

```
envdata.getEnclosed(...........);
```

5.3.2.8 The CMSAuthenticatedDataContentInfo Class

The class `CMSAuthenticatedDataContentInfo` represents an object of type id-ct-authData as defined by the constant `CMS.id_ct_authData`.

Note: Oracle CMS supports HMAC with SHA-1 Message Authentication Code (MAC) Algorithm.

Table 5–9 lists some useful methods of this class.

Table 5–9 Useful Methods of CMSAuthenticatedDataContentInfo

Method	Description
void addRecipient(AlgorithmIdentifier keyEncryptionAlgID, SecretKey keyEncryptionKey, byte[] keyIdentifier, java.util.Date keyDate, ASN1Sequence otherKeyAttribute)	Adds a recipient using the key wrap key exchange mechanism
void addRecipient(CMSRecipientInfoSpec ris)	Adds a recipient using the specified key exchange mechanism
void addRecipient(X509Certificate recipientCert, AlgorithmIdentifier keyEncryptionAlgID)	Adds a recipient using the key transport key exchange mechanism using the IssuerAndSerialNo as the recipient identifier
void addRecipient(X509Certificate recipientCert, AlgorithmIdentifier keyEncryptionAlgID, boolean useSPKI64)	Adds a recipient using the key transport key exchange mechanism using the SubjectKeyIdentifier as the recipient identifier
AttributeSet getAuthenticatedAttributes()	Returns the Authenticated Attributes
AlgorithmIdentifier getDigestAlgID()	Returns the digest algorithm

Table 5–9 (Cont.) Useful Methods of CMSAuthenticatedDataContentInfo

Method	Description
CMSContentInfo getEnclosed()	Returns the authenticated content
ASN1ObjectID getEnclosedContentType()	Returns the content type of the enclosed content
byte[] getMAC()	Returns the message authentication code
AlgorithmIdentifier getMACAlgID()	Returns the MAC algorithm used for authentication
OriginatorInfo getOriginatorInfo()	Returns the Originator information
AttributeSet getUnauthenticatedAttributes()	Returns the Unauthenticated Attributes
ASN1Integer getVersion()	Returns the version number
boolean isDetached()	Indicates if this object is detached
java.util.Enumeration recipients()	Returns the list of message recipients
void setAuthenticatedAttributes(AttributeSet authenticatedAttributes, AlgorithmIdentifier digestAlgorithm)	Sets the Authenticated attributes
void setEnclosed(CMSContentInfo content)	Sets the authenticated content
void setOriginatorInfo(OriginatorInfo originatorInfo)	Sets the OriginatorInfo
void setUnauthenticatedAttributes(AttributeSet unauthenticatedAttributes)	Sets the unauthenticated attributes
void verifyMAC(PrivateKey privateKey, X509Certificate recipientCert)	Returns the enclosed content after decryption
void verifyMAC(SecretKey symmetricKey, byte[] keyIdentifier)	Returns the enclosed content after decryption
void verifyMAC(SecretKey symmetricKey, byte[] keyIdentifier, Date keyDate)	Returns the enclosed content after decryption
void verifyMAC(SecretKey symmetricKey, byte[] keyIdentifier, Date keyDate, ASN1Sequence otherKeyAttribute)	Returns the enclosed content after decryption
void writeDetached(boolean writeDetachedObject)	Indicates if the authenticated content must be omitted from this object's output encoding

5.3.2.8.1 Constructing a CMS Authenticated-data Object

Take the following steps to create an authenticated-data object:

1. Create an instance of `CMSAuthenticatedDataContentInfo`. In the following example, contentInfo is a `CMSDataContentInfo` object, Triple-DES HMAC key and HMAC with SHA-1 MAC algorithm:

```
SecretKey contentEncryptionKey =
   KeyGenerator.getInstance("DESede").generateKey();
CMSAuthenticatedDataContentInfo auth =
    new CMSAuthenticatedDataContentInfo(contentInfo,
contentEncryptionKey, CMS.hmac_SHA_1);
```

2. Add recipients, keeping in mind the recipient's key management technique.

   - If the recipient uses the key encryption (wrap) key management mechanism:

     ```
     auth.addRecipient(keyEncryptionAlgID, keyEncryptionKey, keyIdentifier,
         keyDate, otherKeyAttribute);
     ```

   - If the recipient key exchange mechanism was specified using a `CMSRecipientInfoSpec` object:

     ```
     auth.addRecipient(ris)
     ```

   - If the recipient uses the key transport (`IssuerAndSerialNo` recipient identifier) key management mechanism:

     ```
     auth.addRecipient(recipientCert, CMS.rsaEncryption);
     ```

   - If the recipient uses the key transport (64-bit `SubjectKeyIdentifier` recipient identifier) key management mechanism:

     ```
     auth.addRecipient(recipientCert, CMS.rsaEncryption, true)
     ```

   - If the recipient uses the key transport (160-bit `SubjectKeyIdentifier` recipient identifier) key management mechanism:

     ```
     auth.addRecipient(recipientCert, CMS.rsaEncryption, false)
     ```

3. Set any optional arguments:

   ```
   auth.setAuthenticatedAttributes(authenticatedAttributes, CMS.md5);
   auth.setOriginatorInfo(originatorInfo);
   auth.setUnauthenticatedAttributes(unauthenticatedAttributes);
   ```

4. Write the CMS authenticated-data object to a file, say `data.p7m`:

   ```
   auth.output(new FileOutputStream("data.p7m"));
   ```

5.3.2.8.2 Reading a CMS Authenticated-data Object

The steps you need to read the object depend on whether you know the object's content type:

1. Open a connection to the `data.p7m` file using `FileInputStream`. If you know that the object stored in the file is of content type `id-ct-authData`:

   ```
   CMSAuthenticatedDataContentInfo authdata =
       new CMSAuthenticatedDataContentInfo(new FileInputStream("data.p7m"));
   ```

   However, if you do not know the content type in advance:

   ```
   CMSContentInfo cmsdata =
       CMSContentInfo.inputInstance(new FileInputStream("data.p7m"));
   if (cmsdata instanceof  CMSAuthenticatedDataContentInfo)
   {
   CMSAuthenticatedDataContentInfo authdata =
                                (CMSAuthenticatedDataContentInfo) cmsdata;
      // .....
   }
   ```

2. To access the information stored in the CMS `authenticated-data` object:

```
int version = authdata.getVersion().intValue();
AlgorithmIdentifier macAlgID = authdata.getMACAlgID();
byte[] macValue = authdata.getMAC();
CMSContentInfo authContentInfo = authdata.getEnclosed();
if (authData.getEnclosedContentType().equals(CMS.id_data))
    CMSDataContentInfo contentInfo = (CMSDataContentInfo)authContentInfo;
```

3. Verify the MAC depending on the recipient information:

```
authdata.verifyMAC(recipientPrivateKey, recipientCert);
```

or

```
authdata.verifyMAC(symmetricKey, keyIdentifier)
```

or

```
authdata.verifyMAC(symmetricKey, keyIdentifier, keyDate)
```

or

```
authdata.verifyMAC(symmetricKey, keyIdentifier, keyDate,
    otherKeyAttribute)
```

5.3.2.8.3 Detached Authenticated-data CMS Objects

While you can read in a detached authenticated-data object as shown earlier, the MAC verification will fail because the original object that was authenticated is not present. To resolve this, call the `setEnclosed (..)` method to set the authenticated content:

```
authdata.setEnclosed(contentInfo);
```

followed by MAC verification using the appropriate key exchange mechanism:

```
authdata.verifyMAC(...)
```

5.3.2.9 Wrapped (Triple or more) CMSContentInfo Objects

To wrap a `CMSContentInfo` object in another `CMSContentInfo` object, you simply pass an initialized `CMSContentInfo` object to the enclosing `CMSContentInfo` object through its constructor. Call the `output (..)` method of the enclosing outermost `CMSContentInfo` object to generate the nested object.

5.3.2.9.1 Reading a Nested (Wrapped) CMS Object

The approach to reading a nested object depends on whether you know the outermost content type in advance.

If you do not know the outermost content type in advance, call the static method:

```
CMSContentInfo.inputInstance( ... )
```

If you do know the outermost content type in advance, call the appropriate constructor:

```
new CMS***DataContentInfo( .... )
```

Then, recursively call the `getEnclosed(..)` method to extract the next inner object.

5.3.3 Constructing CMS Objects using the CMS***Stream and CMS***Connector Classes

The CMS**DataContentInfo classes provide the same functionality as the CMS***Stream classes. The primary advantage of the CMS***Stream classes over the CMS**DataContentInfo classes is that CMS objects can be created or read in one pass without having to accumulate all the necessary information.

Table 5–10 lists the content types of the CMS***Stream classes:

Table 5–10 The CMSStream Classes***

Class	Content Type
CMSDigestedDataInputStream, CMSDigestedDataOutputStream	CMS.id_digestedData
CMSSignedDataInputStream, CMSSignedDataOutputStream	CMS.id_signedData
CMSEncryptedDataInputStream, CMSEncryptedDataOutputStream	CMS.id_encryptedData
CMSEnvelopedDataInputStream, CMSEnvelopedDataOutputStream	CMS.id_envelopedData
CMSAuthenticatedDataInputStream, CMSAuthenticatedDataOutputStream	CMS.id_ct_authData

Table 5–11 lists the content types of the CMS***Connector classes:

Table 5–11 The CMSConnector Classes***

Class	Content Type
CMSDigestedDataInputConnector, CMSDigestedDataOutputConnector	CMS.id_digestedData
CMSSignedDataInputConnector, CMSSignedDataOutputConnector	CMS.id_signedData
CMSEncryptedDataInputConnector, CMSEncryptedDataOutputConnector	CMS.id_encryptedData
CMSEnvelopedDataInputConnector, CMSEnvelopedDataOutputConnector	CMS.id_envelopedData
CMSAuthenticatedDataInputConnector, CMSAuthenticatedDataOutputConnector	CMS.id_ct_authData

5.3.3.1 Limitations of the CMS***Stream and CMS***Connector Classes

There are some limitations to CMS***Stream and CMS***Connector classes when processing objects:

1. They cannot verify the digest of a detached CMS `id-digestedData` object.
2. They cannot verify the signature of a detached CMS `id-signedData` object.
3. They cannot verify the MAC of a detached CMS `id-ct-authData` object.

Caution: Always use the CMS**DataContentInfo classes when processing detached objects.

5.3.3.2 Difference between CMS***Stream and CMS***Connector Classes

The CMS***OutputStream class is an output stream filter which wraps the data written to it within a CMS (RFC-2630) ContentInfo structure, whose BER encoding is then written to the underlying output stream. The CMS***OutputConnector class is an output stream filter which likewise wraps the data written to it within a CMS (RFC-2630) `ContentInfo` structure, except that only the values octets of the Content field of the `ContentInfo` structure (minus the explicit [0] tag) are written to the underlying output stream.

The CMS***InputStream class is an input stream filter which reads in a BER encoding of a CMS (RFC-2630) `ContentInfo` structure from the underlying output stream. The CMS***InputConnector class is an input stream filter that expects the underlying input stream to be positioned at the start of the value octets of the `Content` field of the `ContentInfo` structure (after the explicit [0] tag).

CMS***Connectors are useful in creating and reading nested objects.

5.3.3.3 Using the CMS***OutputStream and CMS***InputStream Classes

To construct an object:

1. Create a CMS***OutputStream class of the appropriate content type. All the relevant parameters are passed through the constructor.
2. Write the data being protected to the CMS***OutputStream created in step 1.
3. After all the data is written, close the CMS***OutputStream created in step 1 .

To read an object:

1. Create a CMS***InputStream class of the appropriate content type by passing the underlying input stream through the constructor.
2. Read the protected data from the CMS***InputStream created in step 1 using the `read()` and `read (byte[],...)` methods.
3. Invoke `terminate()` after you have finished reading data from the CMS***InputStream created in step 1. This completes the reading of the object.
4. Invoke the appropriate methods to verify that the protected content is secure.

5.3.3.3.1 CMS id-data Object

The `getData()` method returns the data which can then be written to a CMS***OutputStream or CMS***OutputConnector.

5.3.3.3.2 CMS id-ct-receipt Object

The `getReceiptData()` method returns the encoded receipt which can then be written to a CMS***OutputStream or CMS***OutputConnector.

To read `ESSReceipt` data from the input stream:

```
byte[] rcptData = in.read(...);
ESSReceipt er = new ESSReceipt();
er.inputContent(rcptData);
```

5.3.3.3.3 CMS id-digestedData Object

You will not be able to verify the digest of a detached digested-data object. Setting the boolean parameter writeEContentInfo in the `CMSDigestedDataOutputStream` constructor to false enables you to create a detached digested-data object.

5.3.3.3.4 CMS id-signedData Object

You will not be able to verify the signature of a detached `signed-data` object.

The `CMSSignerInfoSpec` class stores signer-specific information. For every signature you want to add, you will need to create a corresponding `CMSSignerInfoSpec` object which is then passed to the constructor.

Setting the boolean parameter `createExternalSignatures` in the `CMSSignedDataOutputStream` constructor to true enables you to create a detached `signed-data` object or external signatures.

To create a Certificate/CRL only object, do not pass any signer information to the `CMSDSignedDataOutputStream` constructor.

5.3.3.3.5 CMS id-encryptedData Objects

Setting the boolean parameter `writeEncryptedOutput` in the `CMSEncryptedDataOutputStream` constructor to false enables you to create a detached `encrypted-data` object.

5.3.3.3.6 CMS id-envelopedData Objects

The `CMSRecipientInfoSpec` class stores recipient-specific information. For every recipient you want to add, you will need to create a corresponding `CMSRecipientInfoSpec` object which is then passed to the constructor.

Setting the boolean parameter `writeContent` in the `CMSEnvelopedDataOutputStream` constructor to `false` enables you to create a detached `enveloped-data` object.

Key Transport Key Exchange Mechanism

Use the `CMSKeyTransRecipientInfoSpec` class to store recipient information that uses the key transport key management mechanism.

Key Agreement Key Exchange Mechanism

This mechanism is not supported at this time.

Key Encryption (wrap) Key Exchange Mechanism

Use the `CMSKEKRecipientInfoSpec` class to store recipient information that uses the key wrap key management mechanism.

5.3.3.3.7 CMS id-ct-authData Objects

You will not be able to verify the MAC of a detached `authenticated-data` object.

Setting the boolean parameter detachEncapContent in the `CMSAuthenticatedDataOutputStream` constructor to **true** enables you to create a detached `authenticated-data` object.

5.3.3.4 Wrapping (Triple or more) CMS***Connector Objects

You use CMS***OutputConnectors to create nested objects.

Use the following code to create signed, enveloped, digested, and encrypted data and write it to the file `nested.p7m`:

```
// nested.p7m <--- FileOutputStream <--- CMSSignedDataOutputConnector
//     <--- CMSEnvelopedDataOutputConnector <---
//         <----  CMSDigestedDataOutputConnector <---
//              <----  CMSEncryptedDataOutputConnector <---
//                  <---- write the data (byte[] data)

FileOutputStream fos = new FileOutputStream("nested.p7m");
CMSSignedDataOutputConnector conn1 =
    new CMSSignedDataOutputConnector(fos, .....);
CMSEnvelopedDataOutputConnector conn2 =
    new CMSEnvelopedDataOutputConnector(conn1, ...);
CMSDigestedDataOutputConnector conn3 =
    new CMSDigestedDataOutputConnector(conn2, ...);
CMSEncryptedDataOutputConnector conn4 =
    new CMSEncryptedDataOutputConnector(conn3, ...);
OutputStream os = conn4.getOutputStream();
os.write(data);
os.close();
```

To read signed, enveloped, digested, and encrypted data stored in file `nested.p7m`:

```
// nested.p7m ---> FileInputStream ---> CMSSignedDataInputConnector -
//      ---> CMSEnvelopedDataInputConnector ---
//          -----> CMSDigestedDataInputConnector ---
//              ----> CMSEncryptedDataInputConnector ---
//                  ---> read the data (byte[] data)

FileInputStream fos = new FileInputStream("nested.p7m");
CMSSignedDataInputConnector conn1 =
    new CMSSignedDataInputConnector(fos, .....);
CMSEnvelopedDataInputConnector conn2 =
    new CMSEnvelopedDataInputConnector(conn1, ...);
CMSDigestedDataInputConnector conn3 =
    new CMSDigestedDataInputConnector(conn2, ...);
CMSEncryptedDataInputConnector conn4 =
    new CMSEncryptedDataInputConnector(conn3, ...);
InputStream is = conn4.getInputStream();
is.read(data);
```

5.4 The Oracle CMS Java API Reference

The Oracle CMS API Reference (Javadoc) is available at:

Oracle Fusion Middleware CMS Java API Reference for Oracle Security Developer Tools

5.5 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at `http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html`.

6

Oracle S/MIME

This chapter provides an overview of Oracle S/MIME, describes key features and benefits, and explains how to set up and use Oracle S/MIME.

This chapter contains these topics:

- Oracle S/MIME Features and Benefits
- Setting Up Your Oracle S/MIME Environment
- Developing Applications with Oracle S/MIME
- The Oracle S/MIME Java API Reference
- Example Programs

6.1 Oracle S/MIME Features and Benefits

Oracle S/MIME is a pure Java solution which provides the following features:

- Full support for X.509 Version 3 certificates with extensions, including certificate parsing and verification
- Support for X.509 certificate chains in PKCS #7 and PKCS #12 formats
- Private key encryption using PKCS #5, PKCS #8, and PKCS #12
- An integrated ASN.1 library for input and output of data in ASN.1 DER/BER format

6.2 Setting Up Your Oracle S/MIME Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME`. This section explains how to set up your environment for Oracle S/MIME. It contains these topics:

- System Requirements for Oracle S/MIME
- Setting the CLASSPATH Environment Variable

6.2.1 System Requirements for Oracle S/MIME

In order to use Oracle S/MIME, your system must have the Java Development Kit (JDK) version 1.5 or higher. Oracle S/MIME also requires:

- An implementation of the JavaBeans Activation Framework (JAF). Sun's royalty-free implementation is available at:

http://java.sun.com/javase/technologies/desktop/javabeans/jaf/downloads/index.html

- An implementation of the JavaMail API. Sun's royalty-free implementation is available at:

  http://www.javasoft.com/products/javamail/index.html

If you are using POP or IMAP, be sure to download Sun's POP3 (or IMAP) Provider, which is also available at the JavaMail page.

6.2.2 Setting the CLASSPATH Environment Variable

Your CLASSPATH environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your CLASSPATH:

- osdt_core.jar file
- osdt_cert.jar file
- osdt_cms.jar file
- osdt_smime.jar file
- Your JAF (Java Activation Framework), JavaMail, and POP3 provider installations.

> **Note:** Java Activation Framework is included in JDK 1.6.

Any application using the Oracle S/MIME API must have all the neccessary MIME types registered in its command map.

Some applications, specifically those reading S/MIME entries from a FileDataSource, will need to register the S/MIME file types.

6.2.2.1 Setting the CLASSPATH on Windows

To set the CLASSPATH on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a CLASSPATH environment variable for your user profile. If a CLASSPATH environment variable already exists, select it and click Edit.
5. Add the full path and file names for all the required jar and class files to the CLASSPATH.

   For example, your CLASSPATH might look like this:

```
%CLASSPATH%;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cms.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_smime.jar;
C:\jaf-1.1.1\activation.jar;
C:\javamail-1.4.1\mail.jar;
```

6. Click OK.

6.2.2.2 Setting the CLASSPATH on UNIX

On UNIX, set your CLASSPATH environment variable to include the full path and file names of all of the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cms.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_smime.jar:
/usr/lib/jaf-1.1/activation.jar:
/usr/lib/javamail-1.4.1/mail.jar
```

6.3 Developing Applications with Oracle S/MIME

This section describes selected interfaces and classes in the Oracle S/MIME API and illustrates their use. It includes these topics:

- Core Classes and Interfaces
- Supporting Classes and Interfaces
- Using the Oracle S/MIME Classes

Selected methods are described as appropriate.

6.3.1 Core Classes and Interfaces

This section describes core classes and interfaces in the Oracle S/MIME API, and explains how to create and parse S/MIME objects.

Summary of Class Changes in OracleAS 11*g*R1

The following changes apply in OracleAS 11*g*R1:

- oracle.security.crypto.cert.X509 has been replaced with java.security.cert.X509Certificate
- oracle.security.crypto.core.PrivateKey has been replaced with java.security.PrivateKey
- oracle.security.crypto.core.SymmetricKey has been replaced with javax.crypto.SecretKey

The Core Certificate Classes and Interfaces

Core classes and interfaces include:

- The oracle.security.crypto.smime.SmimeObject Interface
- The oracle.security.crypto.smime.SmimeSignedObject Interface
- The oracle.security.crypto.smime.SmimeSigned Class
- The oracle.security.crypto.smime.SmimeEnveloped Class
- The oracle.security.crypto.smime.SmimeMultipartSigned Class
- The oracle.security.crypto.smime.SmimeSignedReceipt Class
- The oracle.security.crypto.smime.SmimeCompressed Class

6.3.1.1 The oracle.security.crypto.smime.SmimeObject Interface

The `oracle.security.crypto.smime.SmimeObject` interface represents an S/MIME object. Classes that implement this interface include:

- `SmimeSigned`
- `SmimeEnveloped`
- `SmimeMultipartSigned`
- `SmimeSignedReceipt`
- `SmimeCompressed`

Methods in this interface include:

```
String generateContentType ()
```

Returns the content type string for this S/MIME object. For example:

```
"application/pkcs7-mime; smime-type=signed-data"
```

```
String generateContentType (boolean useStandardContentTypes)
```

If the argument is *true*, returns the same as `generateContentType()`; if *false*, returns old-style (Netscape) content type string. For example:
"application/x-pkcs7-mime; smime-type=signed-data"

```
void writeTo (java.io.OutputStream os, java.lang.String mimeType)
```

Outputs this object to the specified output stream.

6.3.1.2 The oracle.security.crypto.smime.SmimeSignedObject Interface

The `oracle.security.crypto.smime.SmimeSignedObject` interface extends `SmimeObject`, and specifies methods common to all S/MIME signed objects, including `SmimeSigned` and `SmimeMultipartSigned`.

Methods in this interface include:

```
Vector getCertificates ()
```

Returns the list of certificates included in this S/MIME object's signed content.

```
Vector getCRLs ()
```

Returns the list of certificate revocation lists in the S/MIME object's signed content.

```
javax.mail.internet.MimeBodyPart getEnclosedBodyPart ()
```

Returns the document which was signed.

```
oracle.security.crypto.smime.ess.EquivalentLabels getEquivalentLabels
(java.security.cert.X509Certificate signerCert)
```

Returns the `EquivalentLabels` if present or `null`.

```
oracle.security.crypto.smime.ess.ESSSecurityLabel getESSSecurityLabel
(java.security.cert.X509Certificate signerCert)
```

Returns the `ESSSecurityLabel` if present or `null`.

```
oracle.security.crypto.smime.ess.MLExpansionHistory getMLExpansionHistory(
 java.security.cert.X509Certificate signerCert)
```

Returns the `MLExpansionHistory` attribute if present or `null`.

```
oracle.security.crypto.smime.ess.ReceiptRequest getReceiptRequest(
 java.security.cert.X509Certificate signerCert)
```

Returns the `ReceiptRequest` attribute if present or `null`.

```
oracle.security.crypto.smime.ess.SigningCertificate getSigningCertificate(
 java.security.cert.X509Certificate signerCert)
```

Returns the `SigningCertificate`.

```
void verify (oracle.security.crypto.cert.CertificateTrustPolicy trustPolicy)
```

Returns normally if the signed contents include at least one valid signature according to the specified trust policy, otherwise throws an AuthenticationException.

```
void verifySignature (java.security.cert.X509Certificate signerCert)
```

Returns normally if the signed contents contain a signature which can be validated by the given certificate, otherwise throws an AuthenticationException.

The method can throw a SignatureException, if no signature exists corresponding to the given certificate.

6.3.1.3 The oracle.security.crypto.smime.SmimeSigned Class

The oracle.security.crypto.smime.SmimeSigned class represents an S/MIME signed message (.implements SmimeSignedObject). You may use this class to build a new message or parse an existing one.

Constructors and methods include:

```
SmimeSigned (javax.mail.internet.MimeBodyPart content)
```

Creates a new SmimeSigned object, using the specified MIME body part for the contents to be signed.

```
SmimeSigned ()
```

Creates a new empty SmimeSigned object, which is useful for building a "certificates-only" S/MIME message.

```
SmimeSigned (InputStream is)
```

Creates a new SmimeSigned object by reading its encoding from the specified input stream.

```
void addSignature (java.security.PrivateKey signerKey,
    java.security.cert.X509Certificate signerCert,
    oracle.security.crypto.core.AlgorithmIdentifier digestAlgID)
```

Adds a signature to the message, using the specified private key, certificate, and message digest algorithm.

```
void addSignature (java.security.PrivateKey signerKey,
 java.security.cert.X509Certificate signerCert,
 oracle.security.crypto.core.AlgorithmIdentifier digestAlgID,
      java.util.Date timeStamp)
```

Adds a signature to the message, including a time stamp.

```
void addSignature (java.security.PrivateKey signerKey,
    java.security.cert.X509Certificate signerCert,
    oracle.security.crypto.core.AlgorithmIdentifier digestAlgID,
    SmimeCapabilities smimeCaps)
```

Adds a signature to the message, including S/MIME capabilities.

```
javax.mail.internet.MimeBodyPart getEnclosedBodyPart ()
```

Returns the MIME body part that was signed.

To build a new message, use any of these three constructors:

```
// Create a new S/MIME Signed Message
SmimeSigned sig = new SmimeSigned();

//         -OR-
// Create a new S/MIME Signed Message with a specified MIME body part
MimeBodyPart bp = new MimeBodyPart();
bp.setText("Hello from SendSignedMsg!");
SmimeSigned sig1 = new SmimeSigned(bp);

//         -OR-
// Create a new S/MIME Signed Message with a specified MIME body part
// and a flag switching compression on or off
MimeBodyPart bp = new MimeBodyPart();
bp.setText("Hello from SendSignedMsg!");
boolean useCompression = true;
SmimeSigned sig2 = new SmimeSigned(bp, useCompression);
```

To parse a message, use the constructor that takes a `java.io.InputStream`:

```
InputStream is = Input stream containing message to be parsed
SmimeSigned sig = new SmimeSigned(is);
```

6.3.1.4 The oracle.security.crypto.smime.SmimeEnveloped Class

The `oracle.security.crypto.smime.SmimeEnveloped` class represents an S/MIME enveloped message (implements SmimeObject), and may be used to build a new message or parse an existing one.

Constructors and methods include:

```
SmimeEnveloped (javax.mail.internet.MimeBodyPart content,
    oracle.security.crypto.core.AlgorithmIdentifier contentEncryptionAlgID)
```

Creates a new `SmimeEnveloped` object from the specified MIME body part, using the specified content encryption algorithm.

```
SmimeEnveloped (InputStream is)
```

Creates a new `SmimeEnveloped` object by reading its encoding from the specified input stream.

```
void addRecipient (java.security.cert.X509Certificate cert)
```

Encrypts the message for the recipient using the given public key certificate.

```
byte[] getEncryptedContent ()
```

Returns the contents without decrypting.

```
javax.mail.internet.MimeBodyPart getEnclosedBodyPart (
 java.security.PrivateKey recipientKey,
 java.security.cert.X509Certificate recipientCert)
```

Returns the MIME body part for the recipient specified by `recipientCert`, after decryption using the given recipient private key.

Use the following code to build a new message:

```
// Create a new S/MIME Enveloped Message with a specified MIME body part and a
specified content
// encryption algorithm
MimeBodyPart bp = new MimeBodyPart();
bp.setText("Hello from SendSignedMsg!");
AlgorithmIdentifier algId = AlgID.aes256_CBC;
SmimeEnveloped env = new SmimeEnveloped(bp, algId);
```

To parse a message, use the constructor that takes a `java.io.InputStream`:

```
InputStream is = Input stream containing message to be parsed
    SmimeEnveloped env = new SmimeEnveloped(is);
```

6.3.1.5 The oracle.security.crypto.smime.SmimeMultipartSigned Class

The `oracle.security.crypto.smime.SmimeMultipartSigned` class represents an S/MIME multi-part signed message. A multipart signed message is intended for email clients that are not MIME-aware. This class can be used to build a new message or parse an existing one.

Constructors and methods include:

```
SmimeMultipartSigned (javax.mail.internet.MimeBodyPart bodyPart,
    oracle.security.crypto.core.AlgorithmIdentifier digestAlgID)
```

Creates a new `SmimeMultipartSigned` message, with the specified MIME body part and message digest algorithm.

```
void addBodyPart (javax.mail.BodyPart part)
```

Inherited from `javax.mail.Multipart`, adds the specified body part to this `SmimeMultipartSigned` object. (See the javax.mail API documentation at `http://java.sun.com/products/javamail/javadocs/javax/mail/BodyPart.html` for more details.)

```
void addSignature (java.security.PrivateKey signerKey,
    java.security.cert.X509Certificate signerCert)
```

Adds a signature to the message, using the specified private key and certificate.

```
void addSignature (java.security.PrivateKey signerKey,
    java.security.cert.X509Certificate signerCert, java.util.Date timeStamp)
```

Adds a signature to the message, using the specified private key and certificate plus a time stamp.

```
void addSignature (java.security.PrivateKey signerKey,
    java.security.cert.X509Certificate signerCert, java.util.Date timeStamp,
    SmimeCapabilities smimeCaps)
```

Adds a signature to the message, using the specified private key and certificate, plus S/MIME capabilities.

```
javax.mail.internet.MimeBodyPart getEnclosedBodyPart ()
```

Returns the MIME body part that was signed.

Use the following code to build a new message:

```
// Create a new S/MIME Multipart Signed Message with a specified
// MIME body part and a specified digest algorithm
MimeBodyPart bp = new MimeBodyPart();
bp.setText("Hello from SendSignedMsg!");
AlgorithmIdentifier algId = AlgID.sha1;
SmimeMutlipartSigned sig = new SmimeMultipartSigned(bp, algId);
```

To parse a message, use the constructor that takes a `javax.activation.DataSource`:

```
DataSource ds = Data source containing message to be parsed
SmimeMultipartSigned sig = new SmimeMultipartSigned(ds);
```

6.3.1.6 The oracle.security.crypto.smime.SmimeSignedReceipt Class

The `oracle.security.crypto.smime.SmimeSignedReceipt` class represents an S/MIME wrapped and signed receipt. You may use this class to build a new message or parse an existing one.

To build a new message, use any of these four constructors:

```
// Create a new S/MIME wrapped and signed receipt with the specified receipt,
// the specified digest of the message's signed attributes
// and the addresses of the receipt recipients
ESSReceipt receipt = ESS receipt to include in message
byte [] msgSigDigest = Digest of signed attributes to be included in message
Address [] addresses = Addresses of receipt recipients
SmimeSignedReceipt sig = new SmimeSigned(receipt, msgSigDigest, addresses);
```

```
 //          -OR-
// Create a new S/MIME wrapped and signed receipt
// with a specified S/MIME Signed Message containing the receipt
SmimeSignedObject sso = S/MIME signed message containing receipt
SmimeSignedReceipt sig1 = new SmimeSignedReceipt(sso);

//          -OR-
// Create a new S/MIME wrapped and signed receipt with a
// specified S/MIME Signed Message containing the receipt,
// the signer's certificate and the addresses of the receipt recipients
SmimeSignedObject sso1 = S/MIME signed message containing receipt
X509Certificate signerCert = The message signer's certificate
Address [] addresses1 = Addresses of receipt recipients
SmimeSignedReceipt sig2 = new SmimeSignedReceipt(sso1, signerCert, addresses1);

//          -OR-

// Create a new S/MIME wrapped and signed receipt with a
// specified S/MIME Signed Message containing the receipt,
// the signer's certificate, the addresses of the receipt recipients and
// a specified MLExpansionHistory attribute.
SmimeSignedObject sso1 = S/MIME signed message containing receipt
X509Certificate signerCert = The message signer's certificate
Address [] addresses1 = Addresses of receipt recipients
MLExpansionHistory mlExpansionHistory = The MLExpansionHistory attribute
SmimeSignedReceipt sig2 =
    new SmimeSignedReceipt(sso1, signerCert, addresses1, mlExpansionHistory);
```

To parse a message, use the constructor that takes a `java.io.InputStream`:

```
InputStream is = Input stream containing message to be parsed
SmimeSignedReceipt sig = new SmimeSignedReceipt(is);
```

6.3.1.7 The oracle.security.crypto.smime.SmimeCompressed Class

The `oracle.security.crypto.smime.SmimeCompressed` class represents an S/MIME compressed message as defined in RFC 3274. You can use this class to build a new message or parse an existing one.

> **Note:** A link to RFC 3274 is available in Appendix A, "References".

Use the following code to build a new message:

```
// Create a new S/MIME Compressed Message with a specified MIME body part
MimeBodyPart bp = new MimeBodyPart();
bp.setText("Hello from SendSignedMsg!");
SmimeCompressed comp = new SmimeCompressed(bp);

//           -OR-
// Create a new S/MIME Compressed Message with a specified MIME body part
// and a specified compression algorithm
MimeBodyPart bp = new MimeBodyPart();
bp.setText("Hello from SendSignedMsg!");
AlgorithmIdentifier algId = Smime.id_alg_zlibCompress;
SmimeCompressed comp = new SmimeCompressed(bp, algId);
```

To parse a message, use the constructor that takes a `java.io.InputStream`:

```
InputStream is = Input stream containing message to be parsed
SmimeCompressed comp1 = new SmimeCompressed(is);
```

6.3.2 Supporting Classes and Interfaces

This section describes Oracle S/MIME supporting classes and interfaces.

6.3.2.1 The oracle.security.crypto.smime.Smime Interface

The `oracle.security.crypto.smime.Smime` interface defines constants such as algorithm identifiers, content type identifiers, and attribute identifiers.

6.3.2.2 The oracle.security.crypto.smime.SmimeUtils Class

The `oracle.security.crypto.smime.SmimeUtils` class contains static utility methods.

Methods of this class include:

```
public static FileDataSource createFileDataSource (File file,
    String contentTypeHeader)
public static FileDataSource createFileDataSource (String name,
    String contentTypeHeader)
```

For transparent handling of multipart or multipart/signed S/MIME types, use these methods instead of directly instantiating a `javax.activation.FileDataSource`.

Note: The default `javax.activation.FileDataSource` included with JAF 1.0.1 does not handle multipart MIME boundaries when used with Javamail 1.1.x.

6.3.2.3 The oracle.security.crypto.smime.MailTrustPolicy Class

The `oracle.security.crypto.smime.MailTrustPolicy` class implements a certificate trust policy (`oracle.security.crypto.cert.CertificateTrustPolicy`) used to verify signatures on signed S/MIME objects.

6.3.2.4 The oracle.security.crypto.smime.SmimeCapabilities Class

The `oracle.security.crypto.smime.SmimeCapabilities` class encapsulates a set of capabilities for an S/MIME object including, for example, the supported encryption algorithms.

A useful method of this class is:

```
void addCapability(oracle.security.crypto.asn1.ASN1ObjectID capabilityID)
```

which adds the capability with the specified object ID to this set of S/MIME capabilities.

6.3.2.5 The oracle.security.crypto.smime.SmimeDataContentHandler Class

The `oracle.security.crypto.smime.SmimeDataContentHandler` class provides the DataContentHandler for S/MIME content types. It implements `javax.activation.DataContentHandler`.

6.3.2.6 The oracle.security.crypto.smime.ess Package

The `oracle.security.crypto.smime.ess` package contains the following classes:

Table 6–1 Classes in the oracle.security.crypto.smime.ess Package

Class	Description
ContentHints	Content hints
ContentReference	Content reference
EquivalentLabels	ESS EquivalentLabels
ESSSecurityLabel	An ESS security label
MLData	Represents the MLData element which is used in the MLExpansionHistory attribute
MLExpansionHistory	Mailing list expansion history
ReceiptRequest	An ESS Receipt Request
ReceiptRequest.AllOrFirstTier	An 'AllOrFirstTier' is a part of the 'ReceiptsFrom' field of a ReceiptRequest
SigningCertificate	An ESS Signing Certificate

6.3.3 Using the Oracle S/MIME Classes

This section describes how to use the Oracle S/MIME SDK to work with multi-part signed messages, create and open digital envelopes, and implement Enhanced Security Services (ESS). It covers these topics:

- Using the Abstract Class SmimeObject
- Signing Messages
- Creating "Multipart/Signed" Entities
- Creating Digital Envelopes
- Creating "Certificates-Only" Messages
- Reading Messages
- Authenticating Signed Messages
- Opening Digital Envelopes (Encrypted Messages)
- Adding Enhanced Security Services (ESS)

6.3.3.1 Using the Abstract Class SmimeObject

`SmimeObject` is an abstract class representing a fundamental S/MIME message content entity. Subclasses of `SmimeObject` include :

- `SmimeSigned`
- `SmimeEnveloped`
- `SmimeMultipartSigned`
- `SmimeSignedReceipt`, and
- `SmimeCompressed`

One of the characteristics of `SmimeObject` implementations is that they "know their own MIME type" -- that is, they implement the `generateContentType` method.

Thus, to place such an object inside a MIME message or body part, follow the same outline that was used in the `SmimeSigned` example:

1. Create the object.
2. Invoke `generateContentType` on the object to obtain a MIME type.
3. Pass the object, together with the generated content type, to the `setContent` method of a `MimeMessage` or `MimeBodyPart` object.

The `SmimeObject` class provides another version of the `generateContentType` method, which takes a boolean parameter. When given *true* as a parameter, `generateContentType` behaves exactly as in the case of no argument. When given *false* as a parameter, `generateContentType` returns the older MIME types required by certain mail clients, including Netscape Communicator 4.0.4. Specifically:

- "application/pkcs7-mime" becomes "application/x-pkcs7-mime"
- "application/pkcs7-signature" becomes "application/x-pkcs7-signature"

6.3.3.2 Signing Messages

Create a signed message, or signed MIME body part, using these steps:

1. Prepare an instance of MimeBodyPart which contains the content you wish to sign. This body part may have any content-type desired. In the following example we create a "text/plain" body part:

   ```
   MimeBodyPart doc = new MimeBodyPart();
   doc.setText("Example signed message.");
   ```

2. Create an instance of `SmimeSigned` using the constructor which takes the MimeBodyPart created earlier as argument.

   ```
   SmimeSigned sig = new SmimeSigned (doc);
   ```

3. Add all desired signatures. For each signature, you need to specify a private key, a certificate for the matching public key, and a message digest algorithm. For example:

   ```
   sig.addSignature (signatureKey, signatureCert, AlgID.sha1);
   ```

   In this example we specified the SHA-1 message digest algorithm. Alternatively, we could have specified the MD5 algorithm by passing `AlgID.md5` as the argument.

4. Place your `SmimeSignedObject` into a `MimeMessage` or `MimeBodyPart`, as appropriate. For example:

   ```
   MimeMessage m = new MimeMessage();
   m.setContent (sig, sig.generateContentType());
   ```

   or

   ```
   MimeBodyPart bp = new MimeBodyPart();
   bp.setContent (sig, sig.generateContentType());
   ```

The `generateContentType` method used in these examples returns a string identifying the appropriate MIME type for the object, which in this case is:

```
application/pkcs7-mime; smime-type=signed-data
```

With these simple steps, you can now transport the MIME message, place the body part containing S/MIME content into a MIME multipart object, or perform any other operation appropriate for these objects. See the JavaMail API for details.

6.3.3.3 Creating "Multipart/Signed" Entities

The SmimeMultipartSigned class provides an alternative way to create signed messages. These messages use the "multipart/signed" mime type instead of "application/pkcs7-mime". The advantage is that the content of the resulting message is readable with non-MIME enabled mail clients, although such clients will not, of course, be able to verify the signature.

Creating a multi-part/signed message is slightly different from creating a signed message. For example, to send a multi-part/signed text message:

```
// create the content text as a MIME body part
MimeBodyPart bp = new MimeBodyPart();
bp.setText("Example multipart/signed message.");
// the constructor takes the signature algorithm
SmimeMultipartSigned sig = new SmimeMultipartSigned(bp, AlgID.sha1);
// sign the content
sig.addSignature(signerKey, signerCert);
// place the content in a MIME message
MimeMessage msg = new MimeMessage();
msg.setContent(sig, sig.generateContentType());
```

The reason for identifying the message digest in the SmimeMultipartSigned constructor is that, unlike the case of application/pkcs7-mime signed data objects, multipart/signed messages require that all signatures use the same message digest algorithm.

The generateContentType method returns the following string:

```
multipart/signed; protocol="application/pkcs7-signature"
```

6.3.3.4 Creating Digital Envelopes

An S/MIME digital envelope (encrypted message) is represented by the SmimeEnveloped class. This is a MIME entity which is formed by encrypting a MIME body part with some symmetric encryption algorithm (eg, Triple-Des or RC2) and a randomly generated session key, then encrypting the session key with the RSA public key for each intended message recipient.

In the following example, doc is an instance of MimeBodyPart, which is to be wrapped in an instance of SmimeEnveloped, and recipientCert is the recipient's certificate.

```
SmimeEnveloped env = new SmimeEnveloped(doc, Smime.dES_EDE3_CBC);
env.addRecipient (recipientCert);
```

Any number of envelope recipients may be added by making repeated calls to addRecipient.

6.3.3.5 Creating "Certificates-Only" Messages

It is possible to create an S/MIME signed-data object that contains neither content nor signatures; rather, it contains just certificates, or CRLs, or both. Such entities can be used as a certificate transport mechanism. They have the special content type:

```
application/pkcs7-mime; smime-type=certs-only
```

Here is an example:

```
X509Certificate cert1, cert2;
SmimeSigned certBag = new SmimeSigned();
certBag.addCertificate(cert1);
certBag.addCertificate(cert2);
```

Now you can pass `certBag` to an appropriate `setContent` method. When `generateContentType` is invoked on `certBag`, it will automatically return a content type with the correct "certs-only" value for the `smime-type` parameter.

6.3.3.6 Reading Messages

The basic JavaMail API technique for extracting Java objects from MIME entities is to invoke the `getContent()` method on an instance of `MimePart`, an interface which models MIME entities and is implemented by the `MimeMesage` and `MimeBodyPart` classes.

The `getContent` method consults the currently installed default command map - which is part of the JavaBeans Activities Framework - to find a data content handler for the given MIME type, which is responsible for converting the content of the MIME entity into a Java object of the appropriate class.

The `mailcap` file provided with your distribution can be used to install the `SmimeDataContentHandler` class, which serves as a data content handler for the following types:

Content Type	Returns Instance Of
application/pkcs7-mime	SmimeSigned or Smime Enveloped
application/pkcs7-signature	SmimeSigned
application/pkcs10	oracle.security.crypto.cert.CertificateRequest
multipart/signed	SmimeMultipartSigned

6.3.3.7 Authenticating Signed Messages

Once you obtain an instance of `SmimeSigned` or `SmimeMutlipartSigned` from `getContent()`, you will naturally want to verify the attached signatures. To explain the available options for signature verification, it is neccessary to discuss the structure of an S/MIME signed message.

The content of a signed S/MIME message is a CMS object of type `SignedData`. Such an object itself has a content - the document to which the signatures are applied - which is the text encoding of a MIME entity. It also contains from zero to any number of signatures, and, optionally, a set of certificates, CRLs, or both, which the receiving party may use to validate the signatures.

The `SmimeSigned` and `SmimeMultipartSigned` classes encapsulate all of this information. They provide two authentication methods: `verifyingSignature` and `verify`.

To verify a particular signature with a certificate already in possession, ignoring any certificate and CRLs attached by the signer, use `verifySignature`. For example:

```
SmimeSignedObject sig =
    (SmimeSignedObject)msg.getContent(); // msg is a Message
sig.verifySignature(cert, msg.getFrom()); // cert is an X509Certificate object
```

If verification fails, the `verifySignature` method throws either a `SignatureException` or an `AuthenticationException` ; otherwise, it returns normally.

Use `verify` to verify that the content contains at least one valid signature; that is, there exists a valid certificate chain, starting from a trusted root CA, and terminating in a certificate for the private key which generated the signature. This method makes use of the attached certificate and CRLs in order to follow certificate chains.

For example, given a trusted certificate authority (CA) certificate already in hand:

```
TrustedCAPolicy trusts = new TrustedCAPolicy();
// if true, need CRL for each cert in chain
trusts.setRequireCRLs(false);
// caCert is an X509Certificate object with CA cert
trusts.addTrustedCA(caCert);
SmimeSignedObject sig = (SmimeSignedObject)msg.getContent();
sig.verify(trusts, msg.getFrom());
```

Like `verifySignature`, `verify` throws an `AuthenticationException` if the signature cannot be verified; otherwise it returns normally. In either case you can recover the document that was signed, which is itself a MIME entity, by invoking `getEnclosedBodyPart()`:

```
MimeBodyPart doc = sig.getEnclosedBodyPart();
```

6.3.3.8 Opening Digital Envelopes (Encrypted Messages)

An S/MIME digital envelope consists of:

- A protected MIME body part, which has been encrypted with a symmetric key algorithm (for example, DES or RC2)
- A randomly generated content encryption key
- Information that allows one or more intended recipients to decrypt the content

For each recipient, this information consists of the content encryption key, itself encrypted with the recipient's public key.

To obtain the encrypted content from an `SmimeEnveloped` object, you need the recipient's private key and the corresponding certificate; the certificate is used as an index into the recipient information table contained in the envelope's data structure.

For example:

```
SmimeEnveloped env = (SmimeEnveloped)msg.getContent();
MimeBodyPart mbp = env.getEnclosedBodyPart(privKey, cert)
// privKey is a PrivateKey object
// cert is an X509Certificate object
```

Passing the private key and the certificate to the `getEnclosedBodyPart` method returns the decrypted content as an instance of `MimeBodyPart`.

The `getContent` method can now be invoked on the `MimeBodyPart` object to retrieve the (now decrypted) content. This content may be a `String` (in the case of an encrypted text message), or any other object such as an `SmimeSigned`.

6.3.3.9 Adding Enhanced Security Services (ESS)

You can add the ESS services `ReceiptRequests`, `SecurityLabels`, and `SigningCertificates` to an S/MIME signed message by adding them to the `signedAttributes` of a signature.

```
// Create a Signed Message
SmimeSigned sig = new SmimeSigned();
    AttributeSet signedAttributes = new AttributeSet();
```

Receipt Request (oracle.security.crypto.smime.ess.ReceiptRequest)

To request a signed receipt from the recipient of a message, add a receiptRequest attribute to the signedAttributes field while adding a signature:

```
ReceiptRequest rr = new ReceiptRequest();
.........
signedAttributes.addAttribute(Smime.id_aa_receiptRequest, rr);
```

Security Label (oracle.security.crypto.smime.ess.ESSSecurityLabel)

To attach a security label to a message, add an ESSSecurityLabel attribute to the signedAttributes field while adding a signature:

```
ESSSecurityLabel sl = new ESSSecurityLabel();
    .........
    signedAttributes.addAttribute(Smime.id_aa_securityLabel, sl);
```

Signing Certificate
(oracle.security.crypto.smime.ess.SigningCertificate)

To attach a signing certificate to a message, add a SigningCertificate attribute to the signedAttributes field while adding a signature:

```
SigningCertificate sc = new SigningCertificate();
    .........
    signedAttributes.addAttribute(Smime.id_aa_signingCertificate, sc);
```

Use the signedAttributes while adding a signature:

```
sig.addSignature(signerKey, signerCert, digestAlgID, signedAttributes);
```

The ESS signed receipts are generated using the SmimeSignedReceipt class in the oracle.security.crypto.smime package, in a manner similar to using a SmimeSigned class, except that the content that is signed is an oracle.security.crypto.cms.ESSReceipt object.

6.3.3.10 Processing Enhanced Security Services (ESS)

An S/MIME signed receipt must have correctly set content type parameters for the data content handlers to recognize it. If the content type parameters are missing, the signed receipt is treated as a signed message.

6.4 The Oracle S/MIME Java API Reference

The Oracle S/MIME Java API Reference (Javadoc) is located at:

Oracle Fusion Middleware S/MIME Java API Reference for Oracle Security Developer Tools

6.5 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html.

7

Oracle PKI SDK

A **public key infrastructure (PKI)** is a security architecture that provides an increased level of confidence when exchanging information over the Internet.

This chapter provides information about using the packages in Oracle PKI SDK, which is a set of software development kits (SDKs) for developing PKI-aware applications.

This chapter contains the following topics:

7.1 Oracle PKI CMP SDK

This section provides information about using the Oracle public key infrastructure (PKI) Software Development Kit (SDK) for **certificate management protocol (CMP)**. Oracle PKI CMP SDK allows Java developers to quickly implement certificate management functionality such as issuing and renewing certificates, creating and publishing CRLs, and providing key recovery capabilities.

This chapter contains the following topics:

7.1.1 Oracle PKI CMP SDK Features and Benefits

The Oracle PKI CMP SDK provides the following features and functionality:

- Oracle PKI CMP SDK conforms to RFC 2510, and is compatible with other products that conform to this certificate management protocol (CMP) specification. RFC 2510 defines protocol messages for all aspects of certificate creation and management.
- Oracle PKI CMP SDK conforms to RFC 2511, and is compatible with other products that conform to this certificate request message format (CRMF) specification. RFC 2511 describes the Certificate Request Message Format (CRMF), which is used to convey X.509 certificate requests to a Certification Authority (CA).

7.1.1.1 Package Overview for Oracle PKI CMP SDK

The Oracle PKI CMP SDK toolkit contains the following packages:

- The `oracle.security.crypto.cmp` package provides classes that implement certificate management protocol (CMP) as described in RFC 2510, and certificate request message format (CRMF) as described in RFC 2511.
- The `oracle.security.crypto.cmp.attribute` package provides attribute classes for registration controls, registration information, and general information. This package includes the following classes and their subclasses:
  - `RegistrationControl`
  - `RegistrationInfo`
  - `InfoTypeAndValue` (which extends `oracle.security.crypto.cert.AttributeTypeAndValue`)
- The `oracle.security.crypto.cmp.transport` package provides classes for CMP and CRMF transport protocols. It includes the `TCPMessage` class and its specific message-type subclasses.

7.1.2 Setting Up Your Oracle PKI CMP SDK Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME`. This section provides information for setting up your environment for Oracle PKI CMP SDK. It contains the following topics:

- System Requirements for Oracle PKI CMP SDK
- Setting the CLASSPATH Environment Variable

7.1.2.1 System Requirements for Oracle PKI CMP SDK

In order to use Oracle PKI CMP SDK, your system must have the Java Development Kit (JDK) version 1.5 or higher.

7.1.2.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`
- `osdt_cms.jar`
- `osdt_cmp.jar`

7.1.2.2.1 Setting the CLASSPATH on Windows

To set your `CLASSPATH` on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click Edit.

5. Add the full path and file names for all of the required jar and class files to the `CLASSPATH`. For example:

   ```
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cms.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cmp.jar
   ```

6. Click OK.

7.1.2.2.2 Setting the CLASSPATH on UNIX

On UNIX, set your `CLASSPATH` environment variable to include the full path and file names of all the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cms.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cmp.jar
```

7.1.3 The Oracle PKI CMP SDK Java API Reference

The Oracle PKI CMP SDK Java API reference (Javadoc) is available at:

Oracle Fusion Middleware PKI SDK CMP Java API Reference for Oracle Security Developer Tools

7.1.4 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at `hhttp://www.oracle.com/technology/sample_code/products/id_mgmt/index.html`.

7.2 Oracle PKI OCSP SDK

This section provides information about using the Oracle Online Certificate Status Protocol (OCSP) Software Development Kit (SDK). Oracle PKI OCSP SDK allows Java developers to quickly develop OCSP-enabled client applications and OCSP responders that conform to RFC 2560 specifications.

This section contains the following topics:

- Oracle PKI OCSP SDK Features and Benefits
- Setting Up Your Oracle PKI OCSP SDK Environment
- The Oracle PKI OCSP SDK Java API Reference
- Example Programs

7.2.1 Oracle PKI OCSP SDK Features and Benefits

Oracle PKI OCSP SDK provides the following features and functionality:

- Oracle PKI OCSP SDK conforms to RFC 2560 and is compatible with other products that conform to this specification, such as Valicert's Validation Authority. RFC 2560 specifies a protocol useful in determining the current status of a digital certificate without requiring CRLs.

- The Oracle PKI OCSP SDK API provides classes and methods for constructing OCSP request messages that can be sent through HTTP to any RFC 2560 compliant validation authority.
- The Oracle PKI OCSP SDK API provides classes and methods for constructing responses to OCSP request messages, and an OCSP server implementation that you can use as a basis for developing your own OCSP server to check the validity of certificates you have issued.

7.2.2 Setting Up Your Oracle PKI OCSP SDK Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in ORACLE_HOME. This section provides information for setting up your environment for Oracle PKI OCSP SDK. It contains the following topics:

- System Requirements for Oracle PKI OCSP SDK
- Setting the CLASSPATH Environment Variable

7.2.2.1 System Requirements for Oracle PKI OCSP SDK

In order to use Oracle PKI OCSP SDK, your system must have the Java Development Kit (JDK) version 1.5 or higher. Also, make sure that your PATH environment variable includes the Java bin directory.

7.2.2.2 Setting the CLASSPATH Environment Variable

Your CLASSPATH environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your CLASSPATH:

- osdt_core.jar
- osdt_cert.jar
- osdt_ocsp.jar

7.2.2.2.1 Setting the CLASSPATH on Windows

To set your CLASSPATH on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a CLASSPATH environment variable for your user profile. If a CLASSPATH environment variable already exists, select it and click Edit.
5. Add the full path and file names for all of the required jar and class files to the CLASSPATH. For example:

```
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_ocsp.jar
```

6. Click OK.

7.2.2.2.2 Setting the CLASSPATH on Unix

On Unix, set your CLASSPATH environment variable to include the full path and file name of all the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOMEmodules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOMEmodules/oracle.osdt_11.1.1/osdt_ocsp.jar
```

7.2.3 The Oracle PKI OCSP SDK Java API Reference

The Oracle PKI OCSP SDK Java API reference (Javadoc) is available at:

Oracle Fusion Middleware PKI SDK OCSP Java API Reference for Oracle Security Developer Tools

7.2.4 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at `hhttp://www.oracle.com/technology/sample_code/products/id_mgmt/index.html`.

7.3 Oracle PKI TSP SDK

This section provides information about using the Oracle PKI TSP SDK, which allows Java developers to quickly implement time-stamping functionality within a public key infrastructure (PKI) framework.

This section contains the following topics:

- Oracle PKI TSP SDK Features and Benefits
- Setting Up Your Oracle PKI TSP SDK Environment
- The Oracle PKI TSP SDK Java API Reference
- Example Programs

7.3.1 Oracle PKI TSP SDK Features and Benefits

Oracle PKI TSP SDK provides the following features and functionality:

- Oracle PKI TSP SDK conforms to RFC 3161 and is compatible with other products that conform to this time stamp protocol (TSP) specification.
- Oracle PKI TSP SDK provides an example implementation of a TSA server to use for testing TSP request messages, or as a basis for developing your own time stamping service.

7.3.1.1 Class and Interface Overview for Oracle PKI TSP SDK

Oracle PKI TSP SDK contains the following classes and interfaces:

Table 7–1 Oracle PKI TSP SDK Classes and Interfaces

Class or Interface Name	Description
`TSP` Interface	Defines various constants associated with the Time Stamp Protocol (TSP).
`HttpTSPRequest` Class	Implementation of a TSP request message over HTTP.
`HttpTSPResponse` Class	Implementation of a TSP response message over HTTP.
`MessageImprint` Class	This class represents a `MessageImprint` object as defined in RFC 3161.

Table 7–1 (Cont.) Oracle PKI TSP SDK Classes and Interfaces

Class or Interface Name	Description
`TSAPolicyID` Class	This class represents a `TSAPolicyID` object as defined in RFC 3161.
`TSPContentHandlerFactory` Class	A content handler for TSP over HTTP.
`TSPMessage` Class	A TSP message.
`TSPTimeStampReq` Class	A TSP message of type `TimeStampReq` as defined in RFC 3161.
`TSPTimeStampResp` Class	A TSP message of type `TimeStampResp` as defined in RFC 3161.
`TSPUtils` Class	Defines various utility methods for the `oracle.security.crypto.tsp` package.

7.3.2 Setting Up Your Oracle PKI TSP SDK Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in *ORACLE_HOME*. This section provides information for setting up your environment for Oracle PKI TSP SDK. It contains the following topics:

- System Requirements for Oracle PKI TSP SDK
- Setting the CLASSPATH Environment Variable

7.3.2.1 System Requirements for Oracle PKI TSP SDK

In order to use Oracle PKI TSP SDK, your system must have the Java Development Kit (JDK) version 1.5 or higher. Also, make sure that your `PATH` environment variable includes the Java bin directory.

7.3.2.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`
- `osdt_cms.jar`
- `osdt_cmp.jar`
- `osdt_tsp.jar`

7.3.2.2.1 Setting the `CLASSPATH` on Windows

To set your `CLASSPATH` on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click Edit.
5. Add the full path and file names for all the required jar and class files to the `CLASSPATH`. For example:

```
%CLASSPATH%;%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
```

```
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cms.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cmp.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_tsp.jar
```

6. Click OK.

7.3.2.2.2 Setting the CLASSPATH on Unix

On Unix, set your CLASSPATH environment variable to include the full path and file name of all the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cms.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cmp.jar;
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_tsp.jar
```

7.3.3 The Oracle PKI TSP SDK Java API Reference

The Oracle PKI TSP SDK Java API reference (Javadoc) is available at:

Oracle PKI SDK TSP Java API Reference

7.3.4 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html.

7.4 Oracle PKI LDAP SDK

This section provides information about using Oracle PKI LDAP SDK, which allows Java developers to quickly implement operations that involve publishing and retrieving digital certificates from a directory server.

This section contains the following topics:

- Oracle PKI LDAP SDK Features and Benefits
- Setting Up Your Oracle PKI LDAP SDK Environment
- The Oracle PKI LDAP SDK Java API Reference
- Example Programs

7.4.1 Oracle PKI LDAP SDK Features and Benefits

Oracle PKI LDAP SDK provides facilities for accessing a digital certificate within an LDAP directory. Some of the tasks you can perform with Oracle PKI LDAP SDK are:

- Validating a user's certificate in an LDAP directory
- Adding a certificate to an LDAP directory
- Retrieving a certificate from an LDAP directory
- Deleting a certificate from an LDAP directory

7.4.1.1 Class Overview for Oracle PKI LDAP SDK

The `oracle.security.crypto.LDAP` package contains two classes:

- `LDAPCertificateValidator`, which validates a user certificate by checking whether it exists in its subject's LDAP directory entry
- `LDAPUtils`, which is a collection of methods to add, retrieve, and remove certificates from a subject's LDAP directory entry

7.4.2 Setting Up Your Oracle PKI LDAP SDK Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME`. This section provides information on setting up your environment for Oracle PKI LDAP SDK. It contains the following topics:

- System Requirements for Oracle PKI LDAP SDK
- Setting the CLASSPATH Environment Variable

7.4.2.1 System Requirements for Oracle PKI LDAP SDK

To use Oracle PKI LDAP SDK, your system must have the following:

- Java Development Kit (JDK) version 1.5 or higher. Also, make sure that the Java `bin` directory is added to your PATH environment variable.
- Sun Microsystem's Java Naming and Directory Interface (JNDI) version 1.2.1 or higher. You must add all of the JNDI jar files to your `CLASSPATH`.

7.4.2.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`
- `osdt_ldap.jar`
- `jndi.jar, ldapbp.jar, ldap.jar, jaas.jar`, and `providerutil.jar` (Sun's Java Naming and Directory Interface (JNDI))

7.4.2.2.1 Setting the `CLASSPATH` on Windows

To set your `CLASSPATH` on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click Edit.
5. Add the full path and file names for all of the required jar and class files to the `CLASSPATH`. For example:

```
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_ldap.jar;
```

6. Click OK.

7.4.2.2.2 Setting the CLASSPATH on Unix

On Unix, set your CLASSPATH environment variable to include the full path and file name of all the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_ldap.jar
```

7.4.3 The Oracle PKI LDAP SDK Java API Reference

The Oracle PKI LDAP SDK Java API reference (Javadoc) is available at:

Oracle Fusion Middleware PKI SDK LDAP Java API Reference for Oracle Security Developer Tools

7.4.4 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html.

8 Oracle XML Security

XML security refers to standard security requirements of XML documents such as confidentiality, integrity, message authentication, and non-repudiation. The need for **digital signature** and **encryption** standards for XML documents prompted the World Wide Web Consortium (W3C) to put forth an XML Signature standard and an XML Encryption standard.

This chapter describes key features and benefits of Oracle XML Security, and explains how to set up your environment to use Oracle XML Security.

This chapter contains these topics:

> **See Also:** The following resources provide more information about XML and XML standards:
>
> - W3C's Recommendation for XML Signatures
> - W3C's Recommendation for XML Encryption
>
> Links to these resources are available in Appendix A, "References".

8.1 Oracle XML Security Features and Benefits

Oracle Security Developer Tools provide a complete implementation of XML Signature and XML Encryption specification.

8.1.1 Supported Algorithms

Oracle Security Developer Tools provide a complete implementation of the XML Signature and XML Encryption specifications, and support these algorithms:

Signature Algorithms

- DSA with SHA1
- RSA with SHA1
- HMAC-SHA1

Digest Algorithms

- MD5
- SHA1
- SHA256
- SHA512

Transforms

- Canonicalization – Canonical XML 1.0, Canonical XML 1.1, exclusive Canonical XML 1.0, (all forms are supported with and without comments)
- XSLT
- XPath Filter
- XPath Filter 2.0
- Base64 Decode
- Enveloped Signature
- Decrypt Transform

Data Encryption Algorithms

- AES-128 in CBC mode
- AES-192 in CBC mode
- AES-256 in CBC mode
- DES EDE in CBC mode

Key Encryption and Key Wrapping Algorithms

- RSAES-OAEP-ENCRYPT with MGF1
- RSAES-PKCS1-v1_5
- AES-128 Key Wrap
- AES-192 Key Wrap
- AES-256 Key Wrap
- DES-EDE Key Wrap

Links to these standards are available in Appendix A, "References".

8.1.2 Oracle XML Security API

This section describes the Oracle XML Security API.

About the Examples in this Chapter

This chapter contains several sections with instructions and examples of API usage.

- Section 8.3, "How Data is Signed"
- Section 8.4, "How Data is Verified"
- Section 8.5, "How Data is Encrypted"
- Section 8.6, "How Data is Decrypted"

The following sections are specific to the Oracle XML Security API:

- Section 8.7, "About Element Wrappers in the Oracle Security Developer Tools XML APIs"
- Section 8.8, "How to Sign Data with the Oracle XML Security API"
- Section 8.9, "How to Verify Signatures with the Oracle XML Security API"
- Section 8.10, "How to Encrypt Data with the Oracle XML Security API"
- Section 8.11, "How to Decrypt Data with the Oracle XML Security API"

8.2 Setting Up Your Oracle XML Security Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME/modules/oracle.osdt_11.1.1`.

System Requirements

In order to use Oracle XML Security, you must have JDK 5 or higher.

CLASSPATH Environment Variable

Make sure the following items are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`
- `osdt_xmlsec.jar` (This is the main jar containing all the Oracle XML Security classes.)
- `org.jaxen_1.1.1.jar`, which is located in `$ORACLE_HOME/modules/`

  Oracle XML Security relies on the Jaxen XPath engine for XPath processing.

8.3 How Data is Signed

Using the Oracle Security Developer Tools Oracle XML Security API, you can sign an XML document, a fragment of an XML document, or some binary data. This section explains the concepts behind data signing.

The basic steps are as follows:

1. Identify what to sign and where to place the signature.
2. Decide on a signing key.

> **See Also:** For details of data signing with the Oracle XML Security APIs, see Section 8.8 through Section 8.11.

8.3.1 Identify What to Sign

The first step is to identify the data that you need to sign and where your signature will be placed.

The most common case of signing is when you are signing a part of a document, and the signature is also placed in the same document. For this you need to decide how you refer to that part. The simplest way is to use an ID, for example:

```
<myDoc>
  <importantInfo  xml:id="foo1">
    ...
  </importantInfo>
  <dsig:Signature>
    ...
      <dsig:Reference URI="#foo1">
    ...
  </dsig:Signature>
</myDoc>
```

In this example myDoc is the entire document, of which you only want to sign the `<importantInfo>` element, and the signature is placed right after the `<importantInfo>` element. The `<importantInfo>` has an `xml:id` attribute, which the Signature uses to refer to it.

`xml:id` is a generic identifying mechanism.

If your schema does not allow you to add this attribute to your `<importantInfo>` element, you can instead use an Xpath to refer to it.

8.3.1.1 Determine the Signature Envelope

This example uses a "disjoint" signature where the signature and element to be signed are completely separate.

There are two other ways of signing "enveloped":

- where the signature element is the child/descendant of the element to be signed, and
- "enveloping" where the signature element is a parent/ancestor of the element to be signed.

Example of Enveloped Signing

```
<myDoc>
  <importantInfo  xml:id="foo1">
    ...
    <dsig:Signature>
      ...
      <dsig:Reference URI="#foo1">
         ...
```

```
        <Transform Algorithm="...enveloped-signature">
        ...
      </dsig:Reference>
      ...
    </dsig:Signature>
    ...
  </importantInfo>
</myDoc>
```

When you use enveloped signature, you must use the `EnvelopedSignatureTransform` to exclude the signature itself from the signature calculation, otherwise the very act of generating a signature changes the content of the `importtantInfo` element, and the verification will fail.

8.3.1.2 Decide How to Sign Binary Data

It is also possible to sign binary data. To do this you must make the binary data available through a URI. Oracle XML Security allows any URIs that can be resolved by the JDK, such as http:, file:, and zip: URIs.

You need to create a separate XML document which will hold the `Signature` element, and this signature will refer to the binary data using this URI.

Indeed you can sign XML data using this mechanism as well, provided your XML data can be accessed by a URI. But for XML you can decide to either treat it as binary data and sign as is, or apply canonicalization and sign as XML. To apply canonicalization you need to add a canonicalization transform.

If your binary data is present as a base64 encoded string in your XML document, you can use an ID-based or an Xpath-based reference to it, and then use a `Base64DecodeTransform` to decode the data and sign the binary.

```
<myDoc>
  <importantBinaryData  xml:id="foo1">
    XJELGHKLasNDE12KL=
  </importantBinaryData>
  <dsig:Signature>
    ...
      <dsig:Reference URI="#foo1">
        ...
        <Transform Algorithm="...base64">
        ...
      </dsig:Reference>
      ...
  </dsig:Signature>
</myDoc>
```

Note: External URI dereferencing can be very insecure. For example, say you are running Oracle Security Developer Tools code inside a server, and you verify an incoming message; if this message has an external URI reference, it is essentially causing your server to read from the file or from external web sites. This can lead to denial of service attacks and cross-site scripting.

This is why External URI dereferencing is disabled by default. You need to set the JVM property `osdt.allow.externalReferences` (or set `osdt.allow.all`) to allow external URI dereferencing.

8.3.1.3 Sign Multiple XML Fragments with a Signature

You can include multiple XML fragments into the same signature. For example, you can have two ID-based references, and include both of them in the same signature. Or you can use an Xpath expression which resolves to multiple subtrees.

You can also mix and match local ID-based references with remote URI references, and have all of them in the same signature.

In fact it is recommended that you include multiple parts into the same signature to cryptographically bind them together; for example, if you are using an XML signature to sign a purchase order approval, you must include the items that are being purchased, the user who approved it, and time it was approved, all in the same signature. If you forget to include the user, somebody can potentially steal this message, change the user name, resubmit it, and the signature will still verify.

8.3.1.4 Exclude Elements from a Signature

At times you may need to sign subtrees with exclusions, rather than signing complete subtrees; to achieve this you need to use an Xpath expression.

8.3.2 Decide on a Signing Key

Once you have decided what to sign, and how to reference it, you need to decide on a signing key. Options include:

- Use a X509Certificate.

  This is the most common mechanism. You sign with the private key, and anybody who has your public key can verify with it.

- Use a raw asymmetric signing key, like a DSA, RSA, or DH key.

  When you are signing with an X509certificate, you are in fact signing with the DSA/RSA/DH signing key that is associated with the certificate. You can also sign with DSA/RSA/DH signing key that is not associated with any certificate, although there is no good reason for doing so.

- Use a symmetric key.

  You can also do HMAC signing with a symmetric key. This is useful when you and the verifier already share a symmetric key; it could be a key derived from a password, or it could be from a kerberos system which uses symmetric keys. The Oracle Security Developer Tools WS Security APIs provide explicit APIs for password-based keys and kerberos keys.

8.3.2.1 Set Up Key Exchange

The key exchange needs to happen out of band. For example, if you signing with a certificate, the receiver should already be set up with the trust points, so that the receiver can verify your certificate. Or if you are signing with a symmetric key, the receiver should already know this symmetric key. The XML Signature specification does not define this initial key exchange mechanism.

8.3.2.2 Provide a Receiver Hint

You also need to provide a hint to the receiver so that it knows how to verify your signature. This will be in the `<dsig:KeyInfo>` tag inside the `<dsig:Signature>`. This can be accomplished in different ways:

- You can provide no hint at all. This perfectly acceptable, if you have already communicated the key to the receiver, and the receiver is expecting all signatures to be signed by this key. However this is not a likely situation.
- When signing with an `X509Certificate`, you can provide one or more of the following:
  - The entire `X509Certificate`. This is the most common usage.
  - The `Subject` DN of the certificate – This is useful when the receiver has access to a LDAP directory, and it can look up the certificate based on the DN.
  - The `SubjectKeyIdentifier` or the IssuerDN/Serial number pair – This is useful when the receiver is only expecting a signatures from a set of certificates, and it every time it has to verify a signature, it can loop over all the certificates and find the one with matching SKI or `IssuerSerial`.
- When signing with a raw asymmetric key, you can provide the actual values of the RSA/DSA/DH public key. This is not recommended as the receiver cannot verify the key; alternatively, if you include the certificate, the receiver can do PKIX processing and verify it; that is, the receiver can check for certificate validity and check against an OCSP or CRL.
- When signing with a symmetric key, you can provide a key name. This is just a string that conveys some information that the receiver can use to retrieve/construct the symmetric key.

8.4 How Data is Verified

This section explains the concepts behind data verification.

Once you understand how to create a signature, you can use similar steps to verify the signature. The basic steps are as follows:

1. Search for the signature element, and check what was signed

   When you first search for the signature element in the XML document. Oracle XML Security provides a method (put in link here) to list the elements included in this signature. Verify that those are the elements you were expecting to be signed.

2. Fetch the verification key

   Next identify the key with which the signature was signed. To do this, examine the `<dsig:KeyInfo>` for the certificate, raw public key, or symmetric key that should be used for verification.

   > **See Also:** For details of data verification with the Oracle XML Security APIs, see

8.5 How Data is Encrypted

This section explains the concepts behind data encryption.

Using the Oracle XML Security API, you can sign an XML document, a fragment of an XML document or some binary data. The basic steps are as follows:

- Identify what to Encrypt
- Decide on the Encryption Key

See Also: For details of data encryption with the Oracle XML Security APIs, see Section 8.10, "How to Encrypt Data with the Oracle XML Security API".

8.5.1 Identify what to Encrypt

The most common encryption scenario is to encrypt and replace. When you are encrypting a part of the document, replacing the document with the encrypted bytes.

For example:

```
<myDoc>
  <importantInfo>
    ...
  </importantInfo>
</myDoc>
```

If you encrypt the importantInfo element, it will look like this:

```
<myDoc>
  <xenc:EncryptedData>
    ...
  </xenc:EncryptedData>
</myDoc>
```

Here the entire `<importantInfo>` and all its contents are replaced by an `EncryptedData` element which essentially contains a large base64 string, which is the base64 encoding of the encrypted `<importantInfo>` element.

In this mode the `<importantInfo>` element is completely hidden, and the receiver has no way of knowing the contents until it is decrypted.

8.5.1.1 The Content Only Encryption Mode

There is also a "Content only" encryption mode where the element tag itself is not encrypted, but all its contents are encrypted.

```
<myDoc>
  <importantInfo>
    <xenc:EncryptedData>
      ...
    </xenc:EncryptedData>
  </importantInfo>
</myDoc>
```

Use the "Content Only" mode if it is appropriate for everyone to know that the `<importantInfo>` exists; only the intended party will know how to decrypt and look at the contents of the `<importantInfo>` element.

8.5.1.2 Encrypting Binary Data

If you are encrypting binary data present as a base64 encoded string, you can encrypt it as if it were regular XML data.

However if you are encrypting external binary data (that is, data outside the XML document), your options depend on where you will store the encrypted data.

Store Externally

One option is to store the encrypted data externally as well. For SOAP Attachments refer to the WS Security SOAP Attachments (insert link) which specifies a mechanism to encrypt attachments and store the encrypted data back as an attachment.

To store the encrypted data externally, you need to use a `xenc:CipherReference`, which is a subelement of `xencEncryptedData` and uses a URI to refer to the encrypted bytes.

Store Internally

The other option is to store the encrypted bytes inside the `EncryptedData`, just as you would with in-place XML encryption.

8.5.2 Decide on the Encryption Key

This is very similar to the task of deciding the signing key (see section Section 8.3.2, "Decide on a Signing Key") except that you never directly encrypt with an asymmetric key. Instead, you usually:

- choose a random symmetric key,
- encrypt your data with this key,
- encrypt this random symmetric key with your asymmetric key, and
- send both the encrypted data and encrypted key to the receiver.

Even with a symmetric key, you can still choose to:

- generate a random symmetric key,
- encrypt this random symmetric key with your symmetric key and
- send both the encrypted data key and the encrypted key to the receiver

To use this encrypted key mechanism, you need to decide where to place the `xenc:EncryptedKey` in your document.

- If you only have one `encryptedData` element, place the `EncryptedKey` in the `KeyInfo` of the `EncryptedData`.
- Otherwise, place them separately and have one refer to the other.

Use the `<dsig:KeyInfo>` inside the `EncryptedKey` to refer to the certificate, asymmetric key, or key name that can be used to decrypt the `EncryptedKey`.

8.6 How Data is Decrypted

Data decryption follows the same process as for data encryption, but in reverse. The basic steps are as follows:

If the data was encrypted with a simple encryption in place, locate the `EncryptedData` element and look at its `KeyInfo`.

If it is directly encrypted with a known symmetric key, decrypt it.

Otherwise if it is encrypted with a random symmetric key:

- locate the corresponding `EncryptedKey`,
- decrypt it first, and
- use this decrypted random symmetric key to decrypt the `EncryptedData`.

See Also: For details of data decryption with the Oracle XML Security APIs, see

8.7 About Element Wrappers in the Oracle Security Developer Tools XML APIs

All the XML-based Oracle Security Developer Tools APIs like Oracle XML Security, Oracle Web Services Security, Oracle SAML, Oracle XKMS, and Oracle Liberty SDK use a wrapper concept.

For each XML element, there is a corresponding Java wrapper class. For example, the `<dsig:Signature>` XML element corresponds to the `XSSignature` class. All these wrapper classes inherit from `XMLElement`, and they contain only one data member, which is the pointer to the corresponding DOM element.

This section shows how to work with wrapper objects in the Oracle Security Developer Tools APIs.

8.7.1 Construct the Wrapper Object

To construct a wrapper object from the DOM element, simply invoke the constructor.

For example:

```
Element sigElem =
   (Element)doc.getElementsByTagNameNS(XMLURI.ns_dsig, "Signature").item(0);
XSSignature sig = new XSSignature(sigElem);
```

To construct a Wrapper object when the DOM element does not exist, you can either:

- create a DOM element, and use the above method, or
- use a newInstance method

```
XSSignature sig = XSSignature.newInstance(doc, null);
```

This internally achieves the same ends, that is, it creates a `<dsig:Signature>` DOM element, without appending it anywhere, then creates a wrapper object on top of the element. You will need to append this element somewhere in your document.

For some wrapper classes, there is no `newInstance` method and you need to call a constructor that takes the document object.

```
XSSignedInfo sigInfo =  new XSSignedInfo(doc, null);
```

Another way to create the wrapper object from the element is to call the `XMLUtils.getInstance` method:

```
XSSignature sig = (XSSignature)XMLUtils.getInstance(sigElem);
```

The Oracle Security Developer Tools APIs internally maintain a table associating element names to wrapper class names. The XMLUtils.getInstance uses this table to invoke the appropriate constructor and return an instance of that wrapper class.

8.7.2 Obtain the DOM Element from the Wrapper Object

The underlying DOM element is readily available. All wrapper classes extend from XMLElement which provides a method, XMLElement.getElement(), to get the underlying DOM element.

8.7.3 Parse Complex Elements

Whenever there are complex elements containing a hierarchy of subelements, there will also be an equivalent hierarchy of wrapper objects. For example, suppose you have an incoming document containing a signature:

```
<dsig:Signature>
  <dsig:SignedInfo>
    <dsig:CanonicalizationMethod ... />
     ...
  <dsig:SignedInfo>
  <dsig:SignatureValue>..</dsig:SignatureValue>
  ...
</dsig:Signature>
```

Most of these elements have a corresponding wrapper class, such as dsig:Signature -> XSSignature, dsig:SignedInfo -> XSSignedInfo, dsig:SignatureValue -> XSSignatureValue and so on.

But when you construct the XSSignedInfo object from the dsig:Signature DOM element, it does not construct any of the child objects, in fact it does not even look at any of the child elements. The new XSSignature(sigElem) is a quick call which simply creates an object with the data member pointing to the sigElem. The child objects are created every time. So when you call XSSignature.getSignedInfo() it searches the child elements of dsig:Signature to find the dsig:SignedInfo element, constructs a wrapper object on that element, and returns it.

This wrapper object is not stored anywhere. So if you invoke XSSignature.getSignedInfo() again, it does the same thing, returning a different instance of the SignedInfo object; however both these objects point to the same DOM element, so they behave exactly the same way even though they are different instances.

> **Note:** Remember that the DOM is the source of truth, while the wrapper objects are throwaway objects. The get methods always create new wrapper objects, and if you modify the underlying DOM, the wrapper objects always see the most recent changes.

8.7.4 Construct Complex Elements

Consider the same example as before, but now instead of the signature present in an incoming document, you want to create a document containing a signature and send this document to someone.

```
<dsig:Signature>
  <dsig:SignedInfo>
     ...
  <dsig:SignedInfo>
  ...
</dsig:Signature>
```

To construct this complex element, you need to create individual wrapper objects and assemble them using `set` methods.

For example:

```
XSSignature sig = XSSignature.newInstance(doc, null);
XSSignedInfo sigInfo = new XSSignedInfo(doc, null);
sig.setSignedInfo(sigInfo);
```

Remember that the DOM is always the source of truth; the set methods do not store or copy the passed-in wrapper object, they just modify the underlying DOM.

So in this case the `setSignedInfo` gets the `dsig:SignedInfo` element, and makes that a child of the `dsig:Signature` element. So after invoking `setSignedInfo(sigInfo)`, if you do `sigInfo = null`, it will not affect anything.

Finally you need to insert the top-level object somewhere into your DOM:

```
elem.appendChild(sig.getElement());
```

8.8 How to Sign Data with the Oracle XML Security API

This section describes techniques for signing data with the Oracle XML Security APIs.

8.8.1 Basic Procedure to Create a Detached Signature

To create a detached signature like this:

```
<myDoc>
  <importantInfo  xml:id="foo1">
    ...
  </importantInfo>
  <dsig:Signature>
    ...
      <dsig:Reference URI="#foo1">
    ...
  </dsig:Signature>
</myDoc>
```

You need to do this:

```
// assume you have your data set up in doc
Document doc = ...
Element impElem = ...

// Now put an ID on the importantInfo element
impElem.setAttributeNS(XMLURI.ns_xml, "xml:id", "foo1");

// Then get the signing key and certificate from
// somewhere - e.g. you can load them from a keystore
PrivateKey signKey = ...
X509Certificate signCert = ...

// Create the Signature object
XSSignature sig = XSSignature.newInstance(doc, null);

// Create the SignedInfo object
// Normally you should use exclusive canonicalization
//    alg_exclusiveC14N
// Depending on the type of your private key DSA or RSA
//    use dsaWithSHA1 or rsaWithSHA1
XSSignedInfo sigInfo = sig.createSignedInfo(
  XMLURI.alg_exclusiveC14N, XMLURI.alg_rsaWithSHA1, null)
sig.setSignedInfo(sigInfo);


// Create a Reference object to the importantInfo element
// You need to specify the id which you set up earlier,
//  and also a digestMethod
XSReference ref = sig.createReference(null, "#foo1", null,
   XMLURI.alg_sha1);
sigInfo.addReference(ref);
// Create an exclusive c14n Transform object
// If you do not add this transform object, it will use
// inclusive by default
XSAlgorithmIdentifier transform =
  new XSAlgorithmIdentifier(doc, "Transform",
  XMLURI.alg_exclusiveC14n);
ref.addTransform(transform);


// Create a KeyInfo object
XSKeyInfo keyInfo = sig.createKeyInfo();
sig.setKeyInfo(keyInfo);

// Create an X509Data element for your signingCert, inside
//  this keyingo
X509Data x509 = keyInfo.createX509Data(signingCert);
keyInfo.addKeyInfoData(x509);

// Everything is setup, now do the actual signing
// This will actually do all the canonicalization,
// digesting, signing etc
sig.sign(signKey, null);

// Finally insert the signature somewhere in your document
doc.getDocumentElement().appendChild(sig.getElement());
```

Note: After creating a child Wrapper object, you must call a set or add method to put it in its parent, and also remember to insert the top level Signature object into your document.

8.8.2 Variations on the Basic Signing Procedure

Variations on the basic signing procedure include multiple references, enveloped signatures, XPath expressions, certificate hints, and HMAC key signing.

8.8.2.1 Multiple References

To include multiple references in a signature, simply add more XSReference objects to the XSSignedInfo object. Each XSReference object needs its own list of transforms.

8.8.2.2 Enveloped Signature

To use an enveloped signature, add the enveloped signature transform to the reference. This means inserting the following code just before the code that adds the exclusive transform:

```
XSAlgorithmIdentifier transform1 =
  new XSAlgorithmIdentifier(doc, "Transform",
  XMLURI.alg_envelopedSignature);
ref.addTransform(transform1);
```

8.8.2.3 XPath Expression

To use an XPath expression instead of an ID-based reference, pass in an empty string instead of "#foo1" for the URI parameter of `createReference`, then add an XPath transform to the `Reference` as the first transform.

```
String xpathExpr = "ancestor-or-self:importantInfo";
Element xpathElem = doc.createElementNS(XMLURI.ns_dsig,
 "dsig:XPath");
xpathElem.appendChild(doc.createTextNode(xpathExpr);
XSAlgorithmIdentifier transform2 =
  new XSAlgorithmIdentifier(doc, "Transform",
  XMLURI.alg_xpath);
transform2.addParameter(xpathElem);
ref.addTransform(transform2);
```

8.8.2.4 Certificate Hint

If you do not want to include the entire certificate in the key info, but only a hint to the certificate, use the no-argument form of `XSKeyInfo.createX509Data()` and call one of the methods `X509Data.addIssuerSerial`, `addSubjectName`, or `addSubjectKeyID`.

8.8.2.5 Sign with HMAC Key

TO sign with an HMAC key, instead of signing with an RSA or DSA private key, use the `XSSignature.sign(byte[]` secret, `String sigValueId)` method, and pass your HMAC key as the first argument.

Also use a different kind of KeyInfo, such as a KeyName, by calling XSKeyInfo.createKeyName.

8.9 How to Verify Signatures with the Oracle XML Security API

This section explains how to verify signatures using the Oracle XML Security APIs.

8.9.1 Basic Procedure to Check What is Signed

To verify a signature, first locate the `<dsig:Signature>` element in your document, then use it to construct the `XSSignature` wrapper object.

```
Element sigElem = …
XSSignature sig = new XSSignature(sigElem);
```

Next, fetch the `KeyInfo` of the signature and examine the key to determine if you trust the signer. There are different ways to deal with the `KeyInfo`:

- For very simple cases, you may already know the verification key in advance, and you do not need to look at the `KeyInfo` at all.
- In most cases, however, you should look at the `KeyInfo`. One way is to set up callbacks, so when you call `XSSignature.verify()` you call it with no verification key. Internally, the Oracle Security Developer Tools look at the `KeyInfo` to see if it invokes a callback to fetch the key.
- The other option is to proactively look into the `KeyInfo` and determine the key yourself.

8.9.2 Set Up Callbacks

If the KeyInfo Contains the Signing Certificate

If you expect the KeyInfo to contain the signing certificate, and you do not already have this certificate, but you have set up the trust points, you just need to set a certificate validator callback.

```
// Create your certificate validator
CertificateValidator myValidator
  = new CertificateValidator() {
  public void validateCert(CertPath cp) {
     // Code to validate the certificate
  }
};
KeyRetriever.setCertificateValidator(myValidator);
```

The Oracle Security Developer Tools API retrieves the certificate from the `KeyInfo` and invokes your callback; if the callback returns `true`, it will verify with that certificate.

If the KeyInfo Contains a Hint

If you expect the `KeyInfo` to contain only a hint to the signing certificate, that is, the `subjectDN` or Issuer `Serial` or subject key identifier, write a `KeyRetriever` to fetch a certificate from a certificate store given this hint.

If your certificate store is a keystore, a PKCS12 wallet, or a PKCS8 file, you can use one of the built-in retrievers for these types. These retrievers iterate through all the certificates in the keystore or Oracle wallet and find the one which matches the given subjectDN/issuerSerial or SubjectKey.

> **Note:** You can also use this mechanism also if your `KeyInfo` contains the entire certificate; the key retriever will simply match the entire certificate.

```
// Load your keystore
KeyStore ks =
// Set up a callback against this KeyStore
KeyRetriever.addKeyRetriever(
  new KeyStoreKeyRetriever(ks, passwd));
```

8.9.3 Write a Custom Key Retriever

If these built in retrievers are not suitable, you can write a custom `KeyRetriever` by deriving from the `KeyRetriever` class; for example you could do this when you expect the KeyInfo to contain a subjectDN, and you will look up an LDAP directory to find the certificate for that DN.

```
KeyRetriever myRetriever = new KeyRetriever() {
   X509Certificate retrieveCertificate (KeyInfoData keyInfo) {
       // write code to fetch the certificate from
       // the certificate store based on keyInfo
   }

   PublicKey retrieveCertificate (KeyInfoData keyInfo) {
       // write code to fetch the PublicKey from
       // the certificate store based on keyInfo
   }
};
KeyRetriever.addKeyRetriever(myRetriever);
```

If the signature used the symmetric key, and the KeyInfo has the keyname of that key, write a custom key retriever which can fetch the symmetric key based on this key name.

8.9.4 Check What is Signed

The next step is to check if this signature really signs what you were expecting it to sign. The Oracle Security Developer Tools provide an API to return this information:

```
// XSSignature has be created as mentioned before
XSSignature sig = ...

// at first locate the element that are expecting
// to be signed
Element impElem = ...

// Now check if the signature really signs this
List signedObjects = XMLUtils.resolveReferences(sig);
if (signedObjects.size() != 1 ||
   signedObjects.get(0) != impElem {
   // something is wrong - impElem is not signed by
   // this signature
}
```

8.9.5 Verify the Signature

The last step is to actually verify the signature.

8.9.5.1 If Callbacks are Set Up

If you set up callbacks, then make this call:

```
boolean result = sig.verify();
```

You need to check for both a false result and an exception:

- sig.verify() returns false if the signature format is correct, but one of the reference digests does not match, or if the signature does not verify.
- sig.verify() throws an exception if there is something wrong in the construction of the signature; for example, if the algorithm names are wrong or signature bytes are not of the right size.

8.9.5.2 If Callbacks are Not Set Up

If you did not set up callbacks, and you determined the key by yourself, you must call:

- `sig.verify(byte[])` for HMAC keys or
- `sig.verify(PublicKey)` for DSA/RSA keys.

8.9.5.3 Debugging Verification

If you cannot determine why a particular signature does not verify, and you need to debug it, set the JVM property `-Dxml.debug.verify=1`. This flag instructs the Oracle Security Developer Tools to print diagnostic output to the `stderr` for failed signatures.

8.10 How to Encrypt Data with the Oracle XML Security API

This section describes various options for data encryption with Oracle XML Security.

8.10.1 Encrypt with a Shared Symmetric Key

To encrypt and replace the following `<importantInfo>` element:

```
<myDoc>
  <importantInfo>
    ...
  </importantInfo>
</myDoc>
```

you will need to take the following steps:

```
// Assuming there is a shared symmetric key
SecretKey dataEncKey = ...

// Create a new XEEncryptedData instance
// use either obj_Element or obj_Content depending
// on whether you want to encrypt the whole element
// or content only
XEEncryptedData ed = XEEncryptedData
    .newInstance(doc, null, XMLURI.obj_Element);

// Specify the data encryption method
XEEncryptionMethod em =
   ed.createEncryptionMethod(XMLURI.alg_aes128_CBC);
ed.setEncryptionMethod(em);

// Create a Keyinfo with a hint to the symmetric key
XEKeyInfo ki= ed.createKeyInfo();
ki.addKeyInfoData(ki.createKeyName("MyKey"));
ed.setKeyInfo(ki);

// Locate the importantInfo element
Element impElem = ...

// Encrypt the importantInfo element and replace
// it with the EncryptedData element
XEEncrytedData.encryptAndReplace(impElem, dataEncKey,
   null, ed);
```

A Utility Method for Encryption

There is a utility method which performs all these steps:

```
XEncUtils.encryptElement(
  impElem,  // element to be encrypted
  false,    // true = contentOnly, false = entire element
  XMLURI.alg_aes128_CBC, // data encryption alg
  "MyKey" // hint to data key
);
```

8.10.2 Encrypt with a Random Symmetric Key

In Section 8.10.1, "Encrypt with a Shared Symmetric Key", the example made a simplifying assumption that there was a shared symmetric key. In practice, you usually generate a random symmetric key and encrypt with that key, and then encrypt this random symmetric key with the receiver’s public key. Here is how you would do that:

```
// Load up the encryption certificate of the reciever
X509Certificate encCert = ...

// Get the reciever’s public key from the cert
PublicKey keyEncKey = encCert.getPublicKey();

// Then generate a random symmetric key
KeyGenerator keyGen = KeyGenerator.getInstance("AES");
keyGen.init(128);
SecretKey dataEncKey = keyGen.generateKey();

// Now create an EncryptedKey object
XEEncryptedKey = new XEEncryptedKey(doc);

// set up the key encryption algorithm
XEEncryptionMethod em =
  ek.createEncryptionMethod(XMLURI.alg_rsaOAEP_MGF1);
em.setDigestMethod(XMLURI.alg_sha1);
ek.setEncryptionMethod(em);

// encrypt the random symmetric key with public key
byte[] cipherValue = ek.encrypt(dataEncKey, keyEncKey);

// store this cipherValue into ek
XECipherData cd = ek.createCipherData();
cd.setCipherValue(cipherValue);
ek.setCipherData(cd);


// decide on how you would let the receiver know the
// the key encryption key. We are putting in the
// entire reciever’s certificate
XEKeyInfo kki = ek.createKeyInfo();
kki.addKeyInfoData(kki.createX509Data(encCert);

// Now the encrypted key has been set up, let us
// do the data encryption as before
XEncUtils.encryptElement(
  impElem,  // element to be encrypted
  false,    // true = contentOnly, false = entire element
  XMLURI.alg_aes128_CBC, // data encryption alg
  null // No hint to data key
);

// Finally we need to put the EncryptedKey inside the
// KeyInfo of the EncryptedData
ed.addKeyInfoData(ek);
```

A Utility Method for Encryption

There is a utility method which performs all these steps:

```
XEncUtils.encryptElement (
  impElem,  // element to be encrypted
  false,    // true = contentOnly, false = entire element
  XMLURI.alg_aes128_CBC, // data encryption alg
  dataEncKey, // the random symmetric key that we generated
  XMLURI.alg_rsaOAEP_MGF1, // key encryption alg
  KeyEncKey, // public key that we got from cert
  "RecieverCert" // A hint to the certificate
);
```

Notice that this utility method puts KeyName in the EncryptedKey’s KeyInfo; if you want to pass X509Data instead, pass null for keyEncKeyName and then add the X509Data yourself:

```
// use utility method to create EncrytedData
XEEncryptedData ed = XEncUtils...

// no extract EncryptedKey from it
XEEncryptedKey ek = (XEEncryptedKey)ed.getKeyInfo()
 .getEncryptedKeys().elementAt(0);

// Set the keyInfo of the ek
XEKeyInfo kki = ek.createKeyInfo();
kki.addKeyInfoData(kki.createX509Data(encCert);
```

8.11 How to Decrypt Data with the Oracle XML Security API

Decryption techniques depend on whether you have a shared symmetric key or use a random symmetric key.

8.11.1 Decrypt with a Shared Symmetric Key

If you have a shared symmetric key, do the following:

```
// search for the EncryptedData element
Element edElem = ...

// decrypt the data
SecretKey dataDecKey = ...
XEEncrytedData.decryptAndReplace(dataDecKey, edElem, true);
```

8.11.2 Decrypt with a Random Symmetric Key

If you expect to use a random symmetric key:

```
// search for the EncryptedData element
Element edElem = ...
```

```
// decrypt the data
PrivateKey keyDecKey = ...
XEEncUtils.decryptElement(edElem, keyDecKey);
```

8.12 Supporting Classes and Interfaces

This section describes additional classes and interfaces in the Oracle XML Security API.

8.12.1 The oracle.security.xmlsec.util.XMLURI Interface

This interface defines URI string constants for algorithms, namespaces, and objects. It uses the following naming convention:

- Algorithm URIs begin with "alg_".
- Namespace URIs begin with "ns_".
- Object type URIs begin with "obj_".

8.12.2 The oracle.security.xmlsec.util.XMLUtils class

This class contains static utility methods for XML and XML-DSIG. Methods frequently used in applications include the `createDocBuilder()`,`createDocument()`, `toBytesXML()`,and `toStringXML()` methods.

8.13 Common XML Security Questions

This section answers frequently asked questions about XML security and about using Oracle XML Security. It addresses these areas:

What is the DER format? The PEM format? How are these formats used?

DER is an abbreviation for ASN.1 Distinguished Encoding Rules. DER is a binary format that is used to encode certificates and private keys. Oracle XML Security SDK uses DER as its native format, as do most commercial products that use certificates and private keys.

Many other formats used to encode certificates and private keys, including PEM, PKCS #7, and PKCS #12, are transformations of DER encoding. For example, PEM (Privacy Enhanced Mail) is a text format that is the Base 64 encoding of the DER binary format. The PEM format also specifies the use of text `BEGIN` and `END` lines that indicate the type of content that is being encoded.

I received a certificate in my email in a text format. It has several lines of text characters that don't seem to mean anything. How do I convert it into the format that Oracle XML Security uses?

If you received the certificate in your email, it is in PEM format. You need to convert the certificate from PEM (Privacy-Enhanced Mail) format to ASN.1 DER (Distinguished Encoding Rules) format.

How do I use a certificate that is exported from a browser?

If you have exported the certificate from a browser, it is most likely in PKCS #12 format (*.p12 or *.pfx). You must parse the PKCS #12 object into its component parts.

8.14 Best Practices

For a discussion of best practices for implementors and users of the XML Signature specification, see:

http://www.w3.org/TR/xmldsig-bestpractices/

8.15 The Oracle XML Security Java API Reference

The Oracle XML Security API (Javadoc) is available at:

Oracle Fusion Middleware XML Security Java API Reference for Oracle Security Developer Tools

8.16 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html.

9 Oracle SAML

This chapter provides information about using the Oracle Security Assertions Markup Language (SAML) Software Development Kit (SDK). Oracle SAML allows Java developers to develop cross-domain single sign-on and federated access control solutions that conform to the SAML 1.0/1.1 and SAML 2.0 specifications.

This chapter contains the following topics:

- Oracle SAML Features and Benefits
- Oracle SAML 1.0/1.1
- Oracle SAML 2.0

> **See Also:** Section , "Oracle SAML Changes" for information about Oracle Fusion Middleware 11*g* updates.

9.1 Oracle SAML Features and Benefits

The Oracle SAML SDK provides a Java API with supporting tools, documentation, and sample programs to assist developers of SAML-compliant Java security services. Oracle SAML can be integrated into existing Java solutions, including applets, applications, EJBs, servlets, and JSPs.

Oracle SAML provides the following features:

- Support for the SAML 1.0/1.1 and 2.0 specifications
- Support for SAML-based single sign-on (SSO), Attribute, Metadata, Enhanced Client Proxy, and federated identity profiles

> **See Also:** For more information and links to these specifications and related documents, see Appendix A, "References".

9.2 Oracle SAML 1.0/1.1

This section explains how to set up your environment for Oracle SAML 1.0/1.1, how to use Oracle SAML 1.0/1.1, and the classes and interfaces of the Oracle SAML 1.0/1.1 toolkit. It contains the following topics:

- Oracle SAML 1.0/1.1 Packages
- Setting Up Your Oracle SAML 1.0/1.1 Environment
- Classes and Interfaces
- The Oracle SAML 1.0/1.1 Java API Reference
- Example Programs

9.2.1 Oracle SAML 1.0/1.1 Packages

The Oracle SAML Java API contains the following packages for creating SAML 1.0/1.1-compliant Java applications:

oracle.security.xmlsec.saml

This package contains classes that support SAML assertions.

oracle.security.xmlsec.samlp

This package contains classes that support the SAML request and response protocol (SAMLP).

9.2.2 Setting Up Your Oracle SAML 1.0/1.1 Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in ORACLE_HOME.

This section explains how to set up your environment for Oracle SAML 1.0/1.1. It contains these topics:

- System Requirements for Oracle SAML 1.0/1.1
- Setting the CLASSPATH Environment Variable

9.2.2.1 System Requirements for Oracle SAML 1.0/1.1

In order to use Oracle SAML, your system must have the Java Development Kit (JDK) version 1.5 or higher.

9.2.2.2 Setting the CLASSPATH Environment Variable

Your CLASSPATH environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your CLASSPATH:

- osdt_core.jar
- osdt_cert.jar
- osdt_xmlsec.jar
- osdt_saml.jar
- The org.jaxen_1.1.1.jar file (Jaxen XPath engine, included with your Oracle XML Security distribution)

9.2.2.2.1 Setting the CLASSPATH on Windows To set the CLASSPATH on Windows:

1. In your Windows Control Panel, select **System**.
2. In the System Properties dialog, select the **Advanced** tab.
3. Click **Environment Variables**.
4. In the User Variables section, click **New** to add a CLASSPATH environment variable for your user profile. If a CLASSPATH environment variable already exists, select it and click **Edit**.
5. Add the full path and file names for all the required jar files to the CLASSPATH.

   For example, your CLASSPATH might look like this:

```
%CLASSPATH%;%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
```

```
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_xmlsec.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_saml.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_saml2.jar;
%ORACLE_HOME%\modules\org.jaxen_1.1.1.jar;
```

6. Click **OK**.

9.2.2.2.2 Setting the CLASSPATH on UNIX On UNIX, set your CLASSPATH environment variable to include the full path and file name of all the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_xmlsec.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_saml.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_saml2.jar:
$ORACLE_HOME/modules/org.jaxen_1.1.1.jar
```

9.2.3 Classes and Interfaces

This section provides information and code samples for using the classes and interfaces of Oracle SAML 1.0/1.1. It contains these topics:

- Core Classes
- Supporting Classes and Interfaces

9.2.3.1 Core Classes

This section provides a brief overview of the core SAML and SAMLP 1.0/1.1 classes with some brief code examples.

The core classes are:

- The oracle.security.xmlsec.saml.SAMLInitializer Class
- The oracle.security.xmlsec.saml.Assertion Class
- The oracle.security.xmlsec.samlp.Request Class
- The oracle.security.xmlsec.samlp.Response Class

9.2.3.1.1 The oracle.security.xmlsec.saml.SAMLInitializer Class This class initializes the Oracle SAML toolkit. By default Oracle SAML is automatically initialized for SAML v1.0. You can also initialize Oracle SAML for a specific version of the SAML specification. When the `initialize` method is called for a specific version, previously initialized versions will remain initialized. Example 9–1 shows how to initialize the SAML toolkit for SAML v1.0 and SAML v1.1.

Example 9–1 Initializing the Oracle SAML Toolkit

```
// initializes for SAML v1.1
SAMLInitializer.initialize(1, 1);
// initializes for SAML v1.0, done by default
SAMLInitializer.initialize(1, 0);
```

9.2.3.1.2 The oracle.security.xmlsec.saml.Assertion Class This class represents the `Assertion` element of the SAML Assertion schema.

Example 9–2 shows how to create a new `Assertion` element and append it to an existing XML document.

Example 9–2 Creating an Assertion Element and Appending to an XML Document

```
Document doc = Instance of org.w3c.dom.Document;
Assertion assertion = new Assertion(doc);
doc.getDocumentElement().appendChild(assertion);
```

Example 9–3 shows how to obtain `Assertion` elements from an XML document.

Example 9–3 Obtaining Assertion Elements From an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get a list of all Assertion elements in the document

NodeList assrtList =
    doc.getElementsByTagNameNS(SAMLURI.ns_saml, "Assertion");
if (assrtList.getLength() == 0)
    System.err.println("No Assertion elements found.");

// Convert each org.w3c.dom.Node object to a
// oracle.security.xmlsec.saml.Assertion object and process

for (int s = 0, n = assrtList.getLength(); s < n; ++s)
{
    Assertion assertion = new Assertion((Element)assrtList.item(s));
    // Process Assertion element
    ...
}
```

9.2.3.1.3 The oracle.security.xmlsec.samlp.Request Class This class represents the `Request` element of the SAML Protocol schema.

Example 9–4 shows how to create a new `Request` element and append it to an existing XML document.

Example 9–4 Creating a Request Element and Appending to an XML Document

```
Document doc = Instance of org.w3c.dom.Document;
Request request = new Request(doc);
doc.getDocumentElement().appendChild(request);
```

Example 9–5 shows how to obtain `Request` elements from an existing XML document.

Example 9–5 Obtaining Request Elements From an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get a list of all Request elements in the document

NodeList reqList =
    doc.getElementsByTagNameNS(SAMLURI.ns_samlp, "Request");
if (reqList.getLength() == 0)
    System.err.println("No Request elements found.");

// Convert each org.w3c.dom.Node object to a
// oracle.security.xmlsec.samlp.Request object and process
```

```
for (int s = 0, n = reqList.getLength(); s < n; ++s)
{
    Request request = new Request((Element)reqList.item(s));
    // Process Request element
    ...
}
```

9.2.3.1.4 The oracle.security.xmlsec.samlp.Response Class This class represents the `Response` element of the SAML Protocol schema.

Example 9–6 shows how to create a `Response` element and append it to an existing XML document.

Example 9–6 Creating a Response Element and Appending to an XML Document

```
Document doc = Instance of org.w3c.dom.Document;
Response response = new Response(doc);
doc.getDocumentElement().appendChild(response);
```

Example 9–7 shows how to obtain Response elements from an existing XML document.

Example 9–7 Obtaining Response Elements From an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get a list of all Response elements in the document

NodeList respList =
    doc.getElementsByTagNameNS(SAMLURI.ns_samlp, "Response");
if (respList.getLength() == 0)
    System.err.println("No Response elements found.");

// Convert each org.w3c.dom.Node object to a
// oracle.security.xmlsec.samlp.Response object and process

for (int s = 0, n = respList.getLength(); s < n; ++s)
{
    Response response = new Response((Element)respList.item(s));
    // Process Response element
    ...
}
```

9.2.3.2 Supporting Classes and Interfaces

This section provides an overview of the supporting classes and interfaces of Oracle SAML 1.0/1.1:

- The oracle.security.xmlsec.saml.SAMLURI Interface
- The oracle.security.xmlsec.saml.SAMLMessage Class

9.2.3.2.1 The oracle.security.xmlsec.saml.SAMLURI Interface This interface defines URI string constants for algorithms, namespaces, and objects. The following naming conventions are used:

- Action Namespace URIs defined in the SAML 1.0 specifications begin with `action_`.

- Authentication Method Namespace URIs defined in the SAML 1.0 specifications begin with `authentication_method_`.
- Confirmation Method Namespace URIs defined in the SAML 1.0 specifications begin with `confirmation_method_`.
- Namespace URIs begin with `ns_`.

9.2.3.2.2 The oracle.security.xmlsec.saml.SAMLMessage Class This is the base class for all the SAML and SAML extension messages that may be signed and contain an XML-DSIG (digital signature) structure.

9.2.4 The Oracle SAML 1.0/1.1 Java API Reference

The Oracle SAML 1.0/1.1 Java API reference (Javadoc) is available at:

Oracle Fusion Middleware SAML 1.0/1.1 Java API Reference for Oracle Security Developer Tools

9.2.5 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at `http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html`.

9.3 Oracle SAML 2.0

This section explains how to set up your environment for Oracle SAML 2.0, how to use Oracle SAML 2.0, and the classes and interfaces of the Oracle SAML 2.0 toolkit. It contains the following topics:

- Oracle SAML 2.0 Packages
- Setting Up Your Oracle SAML 2.0 Environment
- Classes and Interfaces
- The Oracle SAML 2.0 Java API Reference
- Example Programs

9.3.1 Oracle SAML 2.0 Packages

The Oracle SAML Java API contains the following packages for creating SAML 2.0-compliant Java applications:

`oracle.security.xmlsec.saml2.core`

This package contains classes that support SAML assertions.

`oracle.security.xmlsec.saml2.protocol`

This package contains classes that support the SAML request and response protocol (SAMLP).

oracle.security.xmlsec.saml2.ac

This package contains classes that support the SAML authentication context basic types.

oracle.security.xmlsec.saml2.ac.classes

This package contains classes that support various SAML authentication context classes.

oracle.security.xmlsec.saml2.metadata

This package contains classes that support the SAML metadata.

oracle.security.xmlsec.saml2.profiles.attributes

This package contains classes that support various SAML attribute profiles.

oracle.security.xmlsec.saml2.profiles.sso.ecp

This package contains classes that support the SAML ECP SSO profile.

9.3.2 Setting Up Your Oracle SAML 2.0 Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME`.

This section explains how to set up your environment for Oracle SAML 2.0. It contains these topics:

- System Requirements for Oracle SAML 2.0
- Setting the CLASSPATH Environment Variable

9.3.2.1 System Requirements for Oracle SAML 2.0

In order to use Oracle SAML, your system must have the Java Development Kit (JDK) version 1.5 or higher.

9.3.2.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`
- `osdt_xmlsec.jar`
- `osdt_saml.jar`
- The `org.jaxen_1.1.1.jar` file (Jaxen XPath engine, included with your Oracle XML Security distribution)

9.3.2.2.1 Setting the CLASSPATH on Windows To set the `CLASSPATH` on Windows:

1. In your Windows Control Panel, select **System**.
2. In the System Properties dialog, select the **Advanced** tab.
3. Click **Environment Variables**.
4. In the User Variables section, click **New** to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click **Edit**.
5. Add the full path and file names for all the required jar files to the `CLASSPATH`.

   For example, your `CLASSPATH` might look like this:

```
    %CLASSPATH%;%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
    %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
    %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_xmlsec.jar;
    %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_saml.jar;
    %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_saml2.jar;
    %ORACLE_HOME%\modules\org.jaxen_1.1.1.jar;
```

6. Click **OK**.

9.3.2.2.2 Setting the CLASSPATH on UNIX On UNIX, set your `CLASSPATH` environment variable to include the full path and file name of all the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_xmlsec.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_saml.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_saml2.jar:
$ORACLE_HOME/modules/org.jaxen_1.1.1.jar
```

9.3.3 Classes and Interfaces

This section provides information and code samples for using the classes and interfaces of Oracle SAML 2.0. It contains these sections:

- Core Classes
- Supporting Classes and Interfaces

9.3.3.1 Core Classes

This section provides an overview of the core SAML and SAMLP classes with some brief code examples. The core classes are:

- The oracle.security.xmlsec.saml2.core.Assertion Class
- The oracle.security.xmlsec.saml2.protocol.AuthnRequest Class
- The oracle.security.xmlsec.saml2.protocol.StatusResponseType Class

9.3.3.1.1 The oracle.security.xmlsec.saml2.core.Assertion Class This class represents the Assertion element of the SAML Assertion schema.

Example 9–8 shows how to create a new Assertion element and append it to an existing XML document.

Example 9–8 Creating an Assertion Element and Appending it to an XML Document

```
Document doc = Instance of org.w3c.dom.Document;
Assertion assertion = new Assertion(doc);
doc.getDocumentElement().appendChild(assertion);
```

Example 9–9 shows how to obtain Assertion elements from an XML document.

Example 9–9 Obtaining Assertion Elements From an XML Document

```
// Get a list of all Assertion elements in the document

NodeList assrtList =
    doc.getElementsByTagNameNS(SAML2URI.ns_saml, "Assertion");
if (assrtList.getLength() == 0)
```

```
    System.err.println("No Assertion elements found.");

// Convert each org.w3c.dom.Node object to a
// oracle.security.xmlsec.saml2.core.Assertion object and process

for (int s = 0, n = assrtList.getLength(); s < n; ++s)
{
    Assertion assertion = new Assertion((Element)assrtList.item(s));
    // Process Assertion element
    ...
}
```

9.3.3.1.2 The oracle.security.xmlsec.saml2.protocol.AuthnRequest Class

This class represents the `AuthnRequest` element of the SAML Protocol schema.

Example 9–10 shows how to create a new `AuthnRequest` element and append it to an existing XML document.

Example 9–10 Creating an AuthnRequest Element and Appending it to an XML Document

```
Document doc = Instance of org.w3c.dom.Document;
AuthnRequest request = new AuthnRequest(doc);
doc.getDocumentElement().appendChild(response);
```

Example 9–11 shows how to obtain `AuthnRequest` elements from an existing XML document.

Example 9–11 Obtaining AuthnRequest Elements From an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get a list of all AuthnRequest elements in the document

NodeList reqList =
    doc.getElementsByTagNameNS(SAML2URI.ns_samlp, "AuthnRequest");
if (reqList.getLength() == 0)
    System.err.println("No Request elements found.");

// Convert each org.w3c.dom.Node object to a
// oracle.security.xmlsec.saml2.protocol.AuthnRequest
// object and process

for (int s = 0, n = reqList.getLength(); s < n; ++s)
{
    AuthnRequest request = new AuthnRequest((Element)reqList.item(s));
    // Process Request element
    ...
}
```

9.3.3.1.3 The oracle.security.xmlsec.saml2.protocol.StatusResponseType Class

This class represents the `Response` element of the SAML Protocol schema.

The `samlp:StatusResponseType` element is a base type representing an extension point for the SAML 2.0 protocols. The various protocols defined in the SAML 2.0 specification use sub-types such as `samlp:Response` or `samlp:LogoutResponse`.

Example 9–12 shows how to create a `Response` element and append it to an existing XML document.

Example 9–12 Creating a Response Element and Appending to an XML Document

```
Document doc = Instance of org.w3c.dom.Document;
Response response = new Response(doc);
doc.getDocumentElement().appendChild(response);
```

Example 9–13 shows how to obtain `Response` elements from an existing XML document.

Example 9–13 Obtaining a Response Element and Appending it to an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get a list of all Response elements in the document

NodeList respList =
    doc.getElementsByTagNameNS(SAML2URI.ns_samlp, "Response");
if (respList.getLength() == 0)
    System.err.println("No Response elements found.");

// Convert each org.w3c.dom.Node object to a
// oracle.security.xmlsec.saml2.protocol.Response object and process

for (int s = 0, n = respList.getLength(); s < n; ++s)
{
    Response response = new Response((Element)respList.item(s));
    // Process Response element
    ...
}
```

9.3.3.2 Supporting Classes and Interfaces

This section provides an overview of the supporting classes and interfaces of Oracle SAML 2.0. It includes:

- The oracle.security.xmlsec.saml2.util.SAML2URI Interface

9.3.3.2.1 The oracle.security.xmlsec.saml2.util.SAML2URI Interface This interface defines URI string constants for algorithms, namespaces, and objects. The interface uses these naming conventions:

- Action namespace URIs defined in the SAML 1.0/1.1/2.0 specifications begin with `action_` .
- Authentication method namespace URIs defined in the SAML 1.0/1.1/2.0 specifications begin with `authentication_method_`.
- Confirmation method namespace URIs defined in the SAML 1.0/1.1/2.0 specifications begin with `confirmation_method_` .
- Namespace URIs begin with `ns_`.

9.3.4 The Oracle SAML 2.0 Java API Reference

The Oracle SAML Java API reference (Javadoc) is available at:

Oracle Fusion Middleware SAML 1.0/1.1 Java API Reference for Oracle Security Developer Tools

9.3.5 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at `http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html`.

10

Oracle Web Services Security

Oracle Web Services Security provides a complete implementation of the OASIS WS Security 1.1 standard. This chapter describes how to install and use the SDK.

This chapter contains these topics:

- Setting Up Your Oracle Web Services Security Environment
- Classes and Interfaces
- The Oracle Web Services Security Java API Reference
- Example Programs

The following resources provide more information about Web Services Security:

- OASIS WSS SOAP Message Security Specification
- OASIS WSS Username Token Profile Specification
- OASIS WSS X.509 Certificate Token Profile Specification
- OASIS WSS SAML Assertion Token Profile Specification
- OASIS WSS SWA Token Profile Specification 1.1

> **See Also:** Links to these documents are available in Appendix A, "References".

10.1 Setting Up Your Oracle Web Services Security Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in ORACLE_HOME/modules/oracle.osdt_11.1.1.

To use Oracle Web Services Security, you must have Development Kit (JDK) version 5 or higher.

Make sure the following items are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`
- `osdt_xmlsec.jar` - This is the Oracle XML Security jar.
- `osdt_saml.jar` - This is the Oracle SAML 1.0 and 1.1 jar.
- `osdt_saml2.jar` - This is the Oracle SAML 2.0 jar.
- `org.jaxen_1.1.1.jar`, which is included in `$ORACLE_HOME/modules/`.
- `osdt_wss.jar` - This is the main jar containing Oracle Web Services Security.

- `saaj-api.jar` - This is the standard SAAJ API and is included in JDK6; for previous JDKs, you can obtain it from your JavaEE container.
- `mail.jar, activation.jar` - You can obtain these jars from your JavaEE container.

10.2 Classes and Interfaces

Note: Review Chapter 8, "Oracle XML Security" before proceeding.

This section describes classes and interfaces in the Oracle Web Services Security API. It contains these topics:

- Element Wrappers
- The <wsse:Security> header
- Security Tokens (ST)
- Security Token References (STR)
- Signing and Verifying
- Encrypting and Decrypting

10.2.1 Element Wrappers

Oracle Web Services Security makes use of the concept of element wrappers.

See Also: Section 8.7, "About Element Wrappers in the Oracle Security Developer Tools XML APIs"

Table 10–1 Element Wrappers for Oracle Web Services Security

XML Tag Name	Java Class Name
<wsse:Security>	oracle.security.xmlsec.wss.WSSecurity
<wsse:BinarySecurityToken>	oracle.security.xmlsec.wss.WSSBinarySecurityToken or one of its derived classes depending on the valueType attribute: oracle.security.xmlsec.wss.x509.X509BinarySecurityToken oracle.security.xmlsec.wss.kerberos.KerberosBinarySecurityToken
<wsse: SecurityTokenReference>	oracle.security.xmlsec.wss.WSSecurityTokenReference
<wsse: Embedded>	oracle.security.xmlsec.wss.WSSEmbedded
<wsse11:EncryptedHeader>	oracle.security.xmlsec.wss.WSSEncryptedHeader
<wsse11:SignatureConfirmation>	oracle.security.xmlsec.wss.WSSignatureConfirmation
<wsse:KeyIdentifier>	oracle.security.xmlsec.wss.WSSKeyIdentifier or one of its derived classes depending on the valueType attribute: oracle.security.xmlsec.wss.x509.X509KeyIdentifier oracle.security.xmlsec.wss.saml.SAMLAssertionKeyIdentifier oracle.security.xmlsec.wss.saml2.SAML2AssertionKeyIdentifier oracle.security.xmlsec.wss.kerberos.KerberosKeyIdentifier oracle.security.xmlsec.wss.WSSEncryptedKeyIdentifier
<wsse:Reference>	oracle.security.xmlsec.wss.WSSReference
<wsu:Created>	oracle.security.xmlsec.wss.WSUCreated

Table 10–1 (Cont.) Element Wrappers for Oracle Web Services Security

XML Tag Name	Java Class Name
<wsu:Expires>	oracle.security.xmlsec.wss.WSUExpires
<wsu:Timestamp>	oracle.security.xmlsec.wss.WSUTimestamp
<wsse:UsernameToken>	oracle.security.xmlsec.wss.username.UsernameToken oracle.security.xmlsec.wss. oracle.security.xmlsec.wss. oracle.security.xmlsec.wss. oracle.security.xmlsec.wss. oracle.security.xmlsec.wss. oracle.security.xmlsec.wss.

As explained in Section 8.7, "About Element Wrappers in the Oracle Security Developer Tools XML APIs", the java classes are only throwaway wrappers, while the DOM elements are the source of truth. You can create these wrapper classes using the appropriate constructor, which takes in the DOM element; you can get the underlying DOM element using the `getElement` method.

10.2.2 The <wsse:Security> header

The WS Security specification defines a new SOAP Header called <wsse:Security>. All security information is to be stored inside this header, namely:

- Security Tokens - Contain user name tokens, certificates, SAML assertion and so on (see next section)
- Timestamp - The current time stamp is often included in the security header, and it is usually included in a signature to prevent replay attacks.
- Signatures - Any signatures are stored inside the header. Even though the signature is in the `Security` header, what it signs is often outside the header - for example, a single signature can sign the SOAP Body, some SOAP attachments, a `UserName` token inside the `Security` header, and a `Timestamp` token in the `Security` header.
- EncryptedKeys - Any encrypted session keys are stored here.
- ReferenceList - Contains a list of all the `EncryptedData` sections.

10.2.2.1 Outgoing Messages

For outgoing messages, you need to create a new `<wsse:Security>` header, add security tokens and then encrypt and/or sign parts of the document. Here is how to accomplish this task:

```
// Assuming we the outgoing message has already been constructed into
// a SOAPMessage object (part of SAAJ API)
SOAPMessage msg = ...

// Now create a new <wsse:Security> Header
// newInstance will internally use SOAPHeader.addHeaderElement
SOAPEnvelope env = msg.getSOAPPart().getEnvelope();
WSSecurity ws = WSSecurity.newInstance(env);

// Add required prefixes to this SOAP header

// Now add some security tokens (refer to the next section on
// how to create security tokens)
UsernameToken ut = ...
```

```
ws.addUsernameToken(ut);

// Create some security token references to this token
// (refer to following sections)
ws.createSTR...

// Now sign or encrypt some data (refer to following sections)
// These should use the above STRs
ws.sign(...);
ws.encryptWithEncKey(...);
ws.encryptNoEncKey(...);
```

10.2.2.2 Incoming Messages

For incoming messages, you need to look for a particular `<wsse:Security>` header, inspect its contents, and verify or decrypt parts of the document. To accomplish this task:

```
// Assuming we the incoming message has already been constructed into
// a SOAPMessage object (part of SAAJ API)
SOAPMessage msg = ...
```

10.2.3 Security Tokens (ST)

The WS Security specification defines the concept of "security tokens", sometimes abbreviated to ST.

A security token represents an artifact such as a certificate, a kerberos ticket, a user name with password , a Single sign-on token and so on. Usually a key is derived/extracted from this token, and this key is used to encrypt/decrypt sign/verify parts of the message. However, the security token can also be used just as a data object.

Table 10–2 Security Tokens for Oracle Web Services Security

Type of Token (Java Class)	Variations	Keys
Username token oracle.security.xmlsec.wss.username. UsernameToken	▪ With no password ▪ With a SHA1 digest of the password ▪ With the actual password, or a different kind of digest/derived password.	Symmetric key obtained by running KeyDerivation on user's password
X509 certificate oracle.security.xmlsec.wss.x509. X509BinarySecurityToken	▪ Single v3 certificate ▪ Chain of certificates in PKIPath format ▪ Chain of certificates in PKCS7 format	▪ Public key inside certificate ▪ Private key associated with certificate
Kerberos ticket oracle.security.xmlsec.wss.kerberos. KerberosBinarySecurityToken	▪ AP_REQ packet ▪ GSS-wrapped AP_REQ packet	Either the session key present in the ticket, or a subkey.

Table 10–2 (Cont.) Security Tokens for Oracle Web Services Security

Type of Token (Java Class)	Variations	Keys
SAML Assertion 1.1 oracle.security.xmlsec.wss.saml.SAMLAssertionToken **SAML Assertion 2.0** oracle.security.xmlsec.wss.saml2. SAML2AssertionToken	■ holder_of_key ■ sender_vouchers ■ bearer	For holder_of_key the subject's key is used – this is, the key inside the <saml:SubjectConfirmation> which is inside the <saml:Assertion>. For sender_vouches, the key of the attesting entity is used. Keys are not extracted from bearer tokens.

10.2.3.1 Creating a Username Token

First, create a `UsernameToken` and place it inside your `WSSecurity` header. The only mandatory field in the `UsernameToken` is the username:

```
// create a Username token
WSSecurity ws = ...
UsernameToken ut = new UsernameToken(doc);
ut.setUserName("Zoe");

// remember to put this inside your WSSecurity header.
// addUserNameToken puts it at the beginning, you can also
// use a regular DOM method appendChild or insertChild to put it in.
ws.addUsernameToken(ut);

// optionally add an wsu:Id, so you can refer to it
ut.setWsuId("MyUser");
```

Next, decide how to put the password into this token. There are several choices:

1. Add a clear text password. Consider using this technique only when the whole message is being sent over a secure channel like SSL.
2. Add a digest of the password or some other kind of derived password. A digest is not necessarily more secure than a clear text password, as it can also be replayed unless it is protected by a nonce and time.
3. Add a digest of the password using the digest mechanism given in the WS Security specification. This uses the nonce and the `createdDate`.
4. Do not add the password or its digest at all. Instead derive a key from the password and use that to sign the message, to demonstrate knowledge of the key.

```
// For options 1 and 2, use the setPassword method
ut.setPassword("IloveDogs");

// With this mechanism, the reciever should simply call
// UsernameToken.getPassword to check if the password is as expected.

// For option 3, use the setPasswordDigest method, but before doing
// thatfor that you have to  at first set a nonce and a created date.
SecureRandom random = SecureRandom.getInstance("SHA1PRNG");
byte nonce[] = new byte[20];
random.nextBytes(nonce); // compute a 20 byte random nonce
ut.setNonce(nonce);
ut.setCreatedDate(new Date()); // Set the date to now
ut.setPasswordDigest("IloveDogs"); // will compute the digest from
                                   // this clear text password using
```

```
                                        // nonce and createdDate

// For this mechanism, the reciever should use the following
byte nonce[] = ut.getNonce();
.. check against the used nonces, to make sure this is a new nonce
Date createdDate = ut.getCreated();
.. check that this createdDate is within an expected clock skew
boolean valid = ut.isValid(userName, passwd),
// above call will recompute the digest from the passwd
// and the nonce and created date, and check if this digest matches
// the digest in the username token


// For option 4, set the salt and iteration count
SecureRandom random = SecureRandom.getInstance("SHA1PRNG");
byte salt[] = new byte[15];
random.nextBytes(salt); // compute a 15 byte random salt

ut.setSalt(1, salt);
ut.setIteration(1000);
SecretKey key = ut.deriveKey("IloveDogs");
```

Now you can use this secret key to sign or encrypt data.

10.2.3.2 Creating an X509 Token

You can either use the X509BinarySecurityToken constructor followed by the setToken method, or use the equivalent helper method WSSecurity.createBST_X509:

```
WSSecurity ws = ...
X509Certificate cert = ...
X509BinarySecurityToken x509token = WSSecurity.createBST_X509(cert);

// remember to put this inside your WSSecurity header.
// addX509CertificateToken puts it at the beginning, you can also
// use a regular DOM method appendChild or insertChild to put it in.
ws.addX509CertificateToken(x509Token);

// optionally add an wsu:Id, so you can refer to it
x509Token.setWsuId("MyCert");
```

You can also create an X509BinarySecurityToken from a CertPath object if you want to include an entire chain of certificates.

For encryption data with this certificate, you need the public key which you can obtain by using cert.getPublicKey(). For signing, however, you need the private key, which you should maintain in a keystore.

10.2.3.3 Creating a Kerberos Token

Kerberos tokens are used, as a rule, in conjunction with the Java GSS-API.

Client Side

```
//Use JAAS Authentication with Kerberos Login Module

// Set up the config files and then call  login()
// to login using this module. This will cause the client to contact
// the Kerberos Authentication-Service and get a ticket to talk to the
// Kerberos Ticket-Granting-Service
```

```
LoginContext lc = new LoginContext(...);
lc.login();

//Use JAAS Authorization to set the subject into the thread context
Subject.doAs(lc.getSubject(), action)

// The rest of the code should be executed as a Privileged action
// Create a GSSContext to talk to a particular server.

GSSManager gssManager = GSSManager.getInstance();
GSSName serviceName = gssManager.createName(svcPrincipalName, null);
GSSContext gssContext = gssManager.createContext(serviceName, null,
    null, GSSCredential.DEFAULT_LIFETIME);

// Then call initSecContext. this will cause the client to contact
// the Ticket-Granting-Service to obtain a ticket for talking to that
// particular server. The token that is returned by the initSecContext
// is a GSS wrapped AP_REQ packet.
byte[] token = new byte[1];
token = gssContext.initSecContext(token, 0, token.length);

// Create a Kerberos BST using this AP_REQ packet
WSSecurity ws = ...
KerberosBinarySecurityToken kbst = ws.createBST_Kerberos(token,
      WSSURI.vt_GSSKerberosv5);
ws.addKerberosToken(kbst);

// Get the sessionKey that is present inside the AP_REQ packet,
// this is the session that is generated by the TGT and returned
// to the client in the initSecContext class
//
// This getSessionKey call simply calls Subject.getPrivateCredentials
// to get a list of tickets associated with the subject, and then
// iterates through them to find the one to be used for
// for that particular server
SecretKey sessionKey =
   KerberosUtils.getSessionKey(lc.getSubject(),svcPrincipalName);
```

Now you can use this secret key to sign or encrypt data.

Server Side

```
// Use JAAS Authentication and Authorization as for the client
// Create GSSContext will null credentials </b><br>
SSManager manager = GSSManager.getInstance();
GSSContext gssContext = manager.createContext((GSSCredential)null);


// Locate the KerberosBinarySecurityToken in the incoming WSSecurity
// header. You can do this by doing a DOM search
WSSecurity = ...
KerberosBinarySecurityToken kbst = ...


// Now extract the AP_REQ from the BST and call acceptSecContext
byte ap_req[] = kbst.getValue();
gssContext.acceptSecContext(ap_req);

// The context is now extablished. (Note Mutual authentication would
// need one more round trip)
// Now extract the session key
// KerberosUtils.getSession is an overloaded method, and this
// particular one is meant to be used by server. Internally
// it decrypts the ap_req packet using the server's key (or the
// tgtSession key) and extracts the key from the decrypted ap_req
// packet
Subject srvrSubject = ...
SecretKey sessionKey =
   KerberosUtils.getSessionKey(srvrSubject, ap_req);
```

Now you can decrypt or verify using this key.

10.2.3.4 Creating a SAML Assertion Token

Refer to Chapter 8, "Oracle XML Security" for information on how to create `Assertion` objects. From the `Assertion` object you can create a SAML assertion token by simply invoking the `SAMLAssertionToken(Assertion assertion)` constructor.

10.2.4 Security Token References (STR)

The WS Security specification also defines the concept of a "Security token reference", (sometimes abbreviated to STR), which is a mechanism to refer to a security token. A `Signature` or `Encryption` uses this STR mechanism to identify the key that was used to sign or encrypt.

STR typically supports the following mechanisms:

- Direct Reference: The STR uses a URI to refer to the ST.
- Key Identifier: The STR does not use a URI, but instead uses some other mechanism to identify the token, such as the `Issuer` serial for X509 tokens and the assertion ID for SAML tokens. The token may not be in the message at all.
- Embedded: The token is directly embedded in the `KeyInfo`.

10.2.4.1 Creating a direct reference STR

Before creating the STR, first create the token as mentioned earlier, then call `.setWsuId()` to set an ID on that token. Next create the STR with that ID, and finally pass in that STR in the `WSSSignatureParams` or `WSEncryptionParams` as described below.

10.2.4.2 Creating a Reference STR for a username token

```
WSSecurity ws = ...
WSSecurityTokenReference str =
   ws.createSTR_Username_ref("#MyUser");
```

10.2.4.3 Creating a Reference STR for a X509 Token

```
WSSecurity ws = ...
WSSecurityTokenReference str =
   ws.createSTR_X509_Ref("#MyCert");
```

10.2.4.4 Creating a Reference STR for Kerberos Token

```
WSSecurity ws = ...
// use the appropriate value type
String valueType = WSSURI.vt_GSSKerberosv5;
WSSecurityTokenReference str =
   ws.createSTR_KerberosKeyRef ( "#MyToken");
```

10.2.4.5 Creating a Reference STR for a SAML Assertion token

```
WSSecurity ws = ...
WSSecurityTokenReference str =
   ws.createSTR_SAML_Assertion_Ref20("MySAMLAssertion")
```

10.2.4.6 Creating a Reference STR for an EncryptedKey

```
WSSecurity ws = ...
WSSecurityTokenReference str =
  ws.createSTR_EncKeyRef("MyEncKey")
```

10.2.4.7 Creating a Reference STR for a generic token

Instead of using the `createSTR` methods you can also create the reference directly with the appropriate `valueType` and `tokenType`:

```
WSSecurity ws = ...
String uri = "#MyToken";
WSSReference ref = new WSSReference(doc, uri);
ref.setValueType(valueType); // set an optional valueType
WSSecurityTokenReference str = new WSSecurityTokenReference(doc);
str.setTokenType(tokenType); // set an optional tokenType
str.appendChild(ref);
```

10.2.4.8 Creating a Key Identifier STR

A `KeyIdentifier` is another way to refer to a security token that uses some intrinsic property of the token; for example, an `assertionID` for a SAML `Token` or a `Subject Key Identifier` for an X509 token.

`KeyIdentifers` are often used when the token itself is not present in the document. For example, an incoming message can be encrypted with a `X509Cert`, but instead of having that `X509Cert` in the message, it can have only a hint to it, in the form of a `SubjectKeyIdentifier`.

10.2.4.9 Creating a KeyIdentifier STR for an X509 Token

There are three different ways to identify an X509 Token:

1. Issuer Serial: A combination of Issuer DN and Serial number of the certificate
2. Subject Key Identifier : The subject key Identifier of the certificate
3. Thumbprint SHA1: SHA1 of the certificate.

```
X509Certificate cert = ...
```

```
WSSecurity ws = ...
WSSecurityTokenReference str =
   ws.createSTR_X509_IssuerSerial(cert);
// alternatively use ws.createSTR_X509_SKI(cert)
// or ws. createSTR_X509_ThumbprintSHA1(cert)
```

10.2.4.10 Creating a KeyIdentifier STR for a Kerberos Token

Kerberos tokens can be identified by the SHA1 of the AP_REQ packet or of the GSS wrapped AP_REQ packet.

```
byte ap_req[] = ...
WSSecurity ws = ...
String valueType = WSSURI.vt_GSSKerberosv5;
WSSecurityTokenReference str =
   ws.createSTR_KerberosKeyIdSHA1(ap_req, valueType);
```

10.2.4.11 Creating a KeyIdentifier STR for a SAML Assertion Token

SAML assertions can be identified by the Assertion ID.

For local SAML 1.1 assertions use:

```
WSSecurity.createSTR_SAML_AssertionIdv11(byte assertionId[])
```

For remote SAML 1.1 assertions use:

```
createSTR_SAML_AssertionIdv11(
   byte assertionId[], AuthorityBinding authorityBinding)
```

For local SAML 2.0 assertions use:

```
createSTR_SAML_AssertionIdv20(byte assertionId[])
```

For remote SAML 2.0 assertions use a reference URI:

```
createSTR_SAML_Assertion_Ref20("MySAMLAssertion")
```

10.2.4.12 Creating a KeyIdentifier STR for an EncryptedKey

Remote encrypted keys can be identified by their SHA1 hash. Use this function to create the `KeyIdentifier`:

```
createSTR_EncKeySHA1(byte sha1[])
```

10.2.4.13 Adding an STRTransform

An STRTransform is a very useful transform that you add to your signatures. This transform causes a temporary replacement of the STRs wth the corresponding STs while calculating the signature.

For example, you might include an X509 SKI based STR in your reference. Without the `STRTransform` this will result in only the STR reference being included in the signature,that is, only the SKI value. But if you add an `STRTransform`, during the signing and verifiing process the STR will be replaced by the actual X509 Certificate, that is, the entire X509 certificate will be included in the message.

10.2.5 Signing and Verifying

This section contains a discussion of topics on signing and verifying data.

10.2.5.1 Signing SOAP Messages

Take these steps to sign a SOAP message:

1. Decide how you want to identify the data to be signed – the most common mechanism is to use an ID, but instead of an ID you can also use an XPath expression
2. Decide on additional transforms – exclusive c14n and STR transforms are two common transforms that you might add.
3. Decide on the signing key – you can either do HMAC signing with a symmteric key or do RSA/DSA signatures.
4. Decide on how to indicate this signing key to the reciever – for this you usually need to create an STR as mentioned earlier.

10.2.5.1.1 Adding IDs to elements Use the function

```
WSSUtils.addWsuIdToElement(String id, Element element)
```

to add a `wsu:Id` to the element to be signed. You can use this mechanism to add an ID to regular DOM element, or SAAJ objects which also derive from DOM Elements.

You must declare the wsu namespace prefix. For example, you can declare it at the SOAP Envelope level like this

```
SOAPEnvelope env = ...
env.addNamespaceDeclaration("wsu" , WSSURI.ns_wsu);
```

To sign attachments, you must assign a `ContentId` to each attachment. For this you need to use the following method:

```
setContentId(String contentId)
```

of the SAAJ AttachmentPart object.

10.2.5.1.2 Creating the WSSignatureParams object A `WSSSignatureParams` object must be created with all the signing parameters.

Use the following constructor to create the initial `WSSignatureParams` object. If you want to use HMAC signing, pass in a value for `hmacKey`, and null for the `signingKey`; to use asymmetric signing, pass in a value for the `signingKey` and null for `hmacKey`.

```
WSSignatureParams(byte[] hmacKey, PrivateKey signingKey);
```

This constructor assumes `c14nMethod=excC14N`, `digestMethod=SHA1` and `signMethod=hmacSHA/rsaSHA1/dsaSHA1` (depending on the key). If you want different algorithms use the following setters to set them:

```
setDigestMethod(String digestMethod)
setSignMethod(String signMethod)
setC14nMethod(String method)
```

You also need to set the STR that you have created earlier into this object; use the `setKeyInfoData` for setting the STR.

```
setKeyInfoData(KeyInfoData keyInfoData)
```

When signing attachments, you need to set the SOAPMessage into this WSSignatureParams object so that it can resolve the cid references by locating corresponding attachments.

```
setSOAPMessage(SOAPMessage msg)
```

10.2.5.1.3 Specifying Transforms There are two ways to specify transforms - a simpler but limited way, and an advanced and flexible way. For the simple way, you need to set the following parameters in the WSSignatureParams:

```
·setAttachmentContentOnly(boolean)
```

In the simple mode, all cid references automatically get the AttachmentContentOnly transform, but if you call setAttachmentContentOnly(false) then the cid references will get an AttachmentComplete transform

```
·setUsingSTRTransform(boolean)
```

If you set this to true, each reference will be checked whether it points to an STR, if it does an STRTransform will we added to that reference. Note the STRTransform is only added if the reference directly points to an STR, not if the reference points to a an ancestor of an STR.

```
·setC14Nmethod(String)
```

This parameter defaults to exclusive c14n, and specifies both the canonicalization method for each of the references and the canonicalization method for the SignedInfo section.

```
·setUsingDecryptTransfom(boolean)
```

Set this to true if you want a decrypt transform to be added.

10.2.5.1.4 Calling the WSSecurity.sign method Finally call the following method in WSSecurity to perform the actual signing.

```
XSSignature sign (String[] uris, WSSignatureParams sigParams,
XSAlgorithmIdentifier[][] trans)
```

This method creates the <Signature> element, computes digests of each reference and finally computes the signature.

uris is an array of IDs to be signed. A separate <Reference> will be created for each element of this array.

As described earlier there are two ways to specify the transforms – a simple way in which the transform must be null, and the transformation information is specified throught the various set methods mentioned above (in WSSignatureParams). Or a more advanced way where the transform parameter must explicitly specify all the transforms for each reference, that is, trans.length must be equal to uris.length.

10.2.5.2 Verifying SOAP Messages

When verifying a signature you first need to locate the signature elements in the <wsse:Security> header; for this you can use the method

```
WSSecurity ws = ...
List<XSSignature>sigs = ws.getSignatures();
```

This method searches the DOM tree to find all immediate children of `<wsse:Security>` that are `<dsig:Signature>` and then creates `XSSignature` wrapper objects for each of those elements and returns them. (Note the namespace prefixes do not have to use wsse and dsig).

If you already have the verification key in hand, you can call the following method - either pass in an `hmacKey` for HMAC signatures or a `signingKey` for asymmetric key signatures. The `SOAPMessage` is only need when attachments are signed.

```
XSSignature sig = sigs[0];

byte [] hmacKey = ...
PublicKey signingKey = ... ; // Need either hmacKey of signingKey

SOAPMessage msg = null; // needed only for attachments
boolean res = WSSecurity.verify(sig, byte[] hmacKey, signingKey, msg);
```

However, if you do not have the verification key, you need to set up the following callbacks for resolving STR Key Identifiers. Recall that STR Key Identifiers are usually references to tokens outside the document, so Oracle Security Developer Tools cannot locate these tokens unless you explicitly set up these callbacks.

Table 10–3 Callbacks to Resolve STR Key Identifiers

Token Type	Implementation Interface and Registration	Notes
Username Token	Interface: PasswordRetriever	This callback resolves the UsernameToken Reference STRs.
	Registration: UsernameToken.addPasswordRetriever	In the getPassword() callback, return the password corresponding to the user.
		This secret key will be derived from password, iteration count and salt.
		login() and logout() callbacks are not used
	Interface: KeyDerivator Registration: UsernameToken.addKeyDerivator	This callback also resolves the UsernameToken Reference STRs. Use it when you want to use your own key derivation algorithm. In the resolve() callback, derive the key and return it.

Table 10–3 (Cont.) Callbacks to Resolve STR Key Identifiers

Token Type	Implementation Interface and Registration	Notes
X509	Interface: X509KeyIdentifierResolver Registration: X509KeyIdentifier.addResolver	This callback resolves Thumbprint and SKI Key Identifier STRs. Implement the resolve() and getPrivateKey() callbacks to return the certificate and the private key respectively. Note: The private key is not required for verification, but it is required for decryption. If you have an array of certificates, use the X509KeyIdentifier.matches() method to match each cerificate against the passed-in X509 KeyIdentifier.
	Interface: X509IssuerSerialResolver Registration: X509IssuerSerial.addResolver	This callback resolves Issuer Serial Key Identifier STRs. Implement the resolve() and getPrivateKey() callbacks as in the previous case.

Table 10–3 (Cont.) Callbacks to Resolve STR Key Identifiers

Token Type	Implementation Interface and Registration	Notes
Kerberos	Interface: KerberosKeyIdentifierResolver Registration: KerberosKeyIdentifier.addResolver	This callback resolves Kerberos STRs. Implement the resolve() and resolveKey() method to return the ap_req packet and the session key/subkey which corresponds to the SHA1 value present in the KeyIdentifier. If you have an array of ap_req packets, calculate the SHA1 of each one of them, and find the one whose SHA1 matches the value returned by KerberosKeyIdentifier.getValue(). Return this ap_req packet in the resolve() method. For the resolveKey() method you need to take one more step and return they key present inside the ap_Req packet, for this youe can use the KerberosUtils.getSessionKey(Subject, byte[]) method, which decrypts the ap_req packet using the Subject's key and extracts the session key/sub-key from it.
SAML Assertion v1.1	Interface: SAMLAssertionKeyIdentifierResolver Registration: SAMLAssertionKeyIdentifier.addResolver	This callback resolves SAML Assertion KeyIdentifier STRs. Implement the resolve(), getPublicKey() and getPrivateKey() methods to return the SAML assertion, SAMLX509Cert, and private key respectively. (Note: The private key is required only for decryption, not for verification.)
SAML Assertion v 2.0	Interface: SAML2AssertionKeyIdentifierResolver Registration: SAML2AssertionKeyIdentifier.addResolver	See previous notes for SAML Assertion v1.1.

For tokens that use symmetric keys - UserName Token, Kerberos, and EncryptedKey - you need to set up a resolver, because the document does not have this symmetric key, and Oracle Security Developer Tools cannot verify (or decrypt) unless you set the resolvers.

For tokens that use asymmetric keys - SAML Assertions and X509 Tokens - you do not need to set up a resolver if it uses a direct URI reference STR or an embedded token, because in these cases Oracle Security Developer Tools can locate the certificate on its own. However you still need to set up the `CertificateValidator` callback because Oracle Security Developer Tools will not blindly use a certificate in the message unless you have validated the certificate in your callback.

See Also: Chapter 8, "Oracle XML Security"

After you have set up all the resolvers and the `CertificateValidator`, use the following method:

```
SOAPMessage msg = null; // needed only for attachments
boolean searchTokens = true;
boolean res = WSSecurity.verify(sig, searchTokens, msg);
```

This method inspects the Signature's `KeyInfo` and either searches for the certificate, or calls the appropriate resolvers to get the signing key.

You can also use the `WSSecurity.verifyAll` method which searches for signatures and verifies them one by one.

10.2.5.3 Confirming Signatures

You use the `WSSignatureConfirmation` wrapper class to contruct and process signature confirmation elements.

10.2.5.3.1 Signature Confirmation Response Generation For response generation use the following function in WSSecurity:

```
List<WSSignatureConfirmation> createSignatureConfirmations(Document doc);
```

This looks at all the `Signatures` present in the current `WSSecurity` element, and constructs corresponding `SignatureConfirmation` elements in a new document. These could be put in the response's WSSecuirty header.

10.2.5.3.2 Signature Confirmation Response Processing For response processing, first use this function (at request time) to save all the Signature values.

```
String [] getSignatureValues()
```

At response processing time, you can then use this saved list to compare against the incoming `SignatureConfirmations` as follows:

```
boolean verifySignatureConfirmations(String sigValue[])
```

10.2.6 Encrypting and Decrypting

There are two primary encryption methods:

1. With `EncryptedKey`: Encrypt the elements with a random session key, then encrypt this session key into an `<EncryptedKey>` element and place that element in the `<wsse:Security>` header.
2. Without `EncryptedKey`: Encrypt the elements with known symmetric keys, which may be different for each element; construct a `<ReferenceList>` element

with references to each of these encrypted data sections, and place the `<ReferenceList>` in the `<wsse:Security>` header.

> **Note:** While encrypting regular DOM elements is standard practice, you can also encrypt SOAP headers, the SOAP body, and attachments. Special considerations apply for encrypting these objects as explained later.

10.2.6.1 Encrypting SOAP messages with EncryptedKey

First decide on a key to use to encrypt this random session key, then create an STR with the information that the receiver will use to locate this decryption key:

```
Key keyEncKey = ... ;
WSSecurityTokenReference str = ...
```

create a `WSSEncryptionParams` with this information:

```
// Choose a data encryption algorithm - say AES 128
String dataEncAlg = XMLURI.alg_aes128_CBC;

// Either generate a random session key yourself, or set this to
// null to indicate that OSDT should generate it
SecretKey dataEncKey = null;

// Depending on the KeyEncryptionKey that you have chosen choose
// either an RSA key wrap or a symmetric key wrap
String keyEncAlg = XMLURI.alg_rsaOAEP_MGF1;

// Now put all this information into a WSSEncryptionParams
WSSEncryptionParams eParam = new WSSEncryptionParams(
 dataEncAlg, dataEncKey, keyEncAlg, keyEncKey, str);
```

regular DOM element, SOAP headers, the SOAP Body or AttachmentParts:

```
Element elem1 = ... // one object to be encrypted
Element elem2 = … // another object to be encrypted
ArrayList objectList[] = new ArrayList();
objectList.add(elem1);
objectList.add(elem2);
```

Create two more arrays to indicate whether each object is to be encrypted content only, and what IDs will be assigned to the resulting `EncryptedData` objects:

> **Note:** SOAP bodies are always encrypted content only, regardless of what you pass in this flag. For attachments, "not content only" means content plus mime headers.

```
// both these elements are not content only
boolean[] contentOnlys = { false, false };

// After encryption the EncryptedData elements will get these ids
String encDataIds[] = { "id1", "id2" };
```

Finally, call the `encryptWithEncKey` method:

```
WSSecurity ws = ...
XEEncryptedKey encKey = ws.encryptWithEncKey(objectList, contentOnlys,
 encDataIds, eParam);
```

10.2.6.2 Encrypting SOAP messages without EncryptedKey

Use these steps if you do not wish to use an `EncryptedKey`:

Decide on a data encryption key; you can either use the same one for all the EncryptedData sections or a different one for each. Also create an STR with the information that the receiver will use to locate this decryption key, and put into a `WSSEncryptionParams` object:

```
SecretKey dataEncKey = ... ; // assuming 128 bit AES key
String dataEncAlg = XMLURI.alg_aes128_CBC;
WSSecurityTokenReference str = ...

// Now put all this information into a WSSEncryptionParams
WSSEncryptionParams eParam = new WSSEncryptionParams(
 dataEncAlg, dataEncKey, null, null, str);
```

Now create a list of elements to be encrypted as before, along with the associated `contentOnly` and `encDataIds` array:

```
Element elem1 = ... // one object to be encrypted
Element elem2 = … // another object to be encrypted
ArrayList objectList[] = new ArrayList();
objectList.add(elem1);
objectList.add(elem2);

// both these elements are not content only
boolean[] contentOnlys = { false, false };

// After encryption the EncryptedData elements will get these ids
String encDataIds[] = { "id1", "id2" };
```

Finally, call the `encryptWithNoEncKey` method:

```
WSSecurity ws = ...
XEEncryptedKey encKey = ws.encryptWithNoEncKey(objectList,
 contentOnlys, encDataIds, new WSEncryptionParams[]{eParam, eParam});
```

In this example we used the same `encryptionParams` for both elements.

10.2.6.3 Encrypting SOAP Headers into an EncryptedHeader

When you call the encrypt methods on the SOAP header block , with content only set to `false`, the entire SOAP header block is encrypted into an `EncryptedData` element; this element is placed inside an `EncryptedHeader` element, which replaces the original SOAP header block.

The `mustUnderstand` and `actor` attributes are copied over from the current `wsse:Security` header.

10.2.6.4 Decrypting SOAP messages with EncryptedKey

To decrypt SOAP messages with `EncryptedKey`, use:

```
WSSecurity.decrypt(XEEncryptedKey, PrivateKey, SOAPMessage)
```

which first decrypts the `EncryptedKey` with the given `PrivateKey` to obtain a symmetric key, then uses this symmetric key to decrypt all the references inside the `EncrytedKey`.

If you do not know the PrivateKey, call:

```
decrypt(XEEncryptedKey, SOAPMessage)
```

which looks into the KeyInfo of the EncryptedKey and calls the registered callbacks to obtain the private key.

If you already know the decrypted form of the EncryptedKey then use:

```
decrypt(XEEncryptedKey, SecretKey, SOAPMessage)
```

which uses the given symmetric key to decrypt all the references inside the EncryptedKey.

10.2.6.5 Decrypting SOAP messages without EncryptedKey

When you wish to decrypt all the elements (or attachments) mentioned in a top level ReferenceList, use:

```
decrypt(XEReferenceList, SecretKey, SOAPMessage)
```

which uses the given symmetric key to decrypt all the references inside the ReferenceList. This functions assumes that all the references are encrypted with the same key.

If you do not know the SecretKey, or if all the references are not encrypted with the same key, send in a null for the SecretKey; decrypt then looks into the KeyInfo of each of the EncrytedData and calls the registered callbacks to obtain the symmetric key.

10.3 The Oracle Web Services Security Java API Reference

The Oracle Web Services Security API Reference (Javadoc) is available at:

Oracle Fusion Middleware Web Services Security Java API Reference for Oracle Security Developer Tools

10.4 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html.

11 Oracle Liberty SDK

The Liberty Alliance is an open organization that was founded with the goal of allowing individuals and businesses to engage in virtually any transaction without compromising the privacy and security of vital identity information. Specifications issued by the Liberty Alliance are based on an open identity federation framework, allowing partner companies to form business relationships based on a cross-organizational, federated network identity model.

This chapter describes the features and benefits of the Oracle Liberty SDK, and explains how to set up your environment and use Oracle Liberty SDK.

This chapter contains these topics:

11.1 Oracle Liberty SDK Features and Benefits

Oracle Liberty SDK allows Java developers to design and develop **single sign-on (SSO)** and **federated identity management (FIM)** solutions. Oracle Liberty SDK aims to unify, simplify, and extend all aspects of development and integration of systems conforming to the Liberty Alliance ID-FF 1.1 and 1.2 specifications.

Oracle Liberty SDK 1.1 and 1.2 enable simplified software development through the use of an intuitive and straightforward Java API. The toolkits provide tools, information, and examples to help you develop solutions that conform to the Liberty Alliance specifications. The toolkits can also be seamlessly integrated into any existing Java solution, including applets, applications, EJBs, servlets, JSPs, and so on.

The Oracle Liberty SDK is a pure java solution which provides the following features:

- Support for the Liberty Alliance ID-FF version 1.1 and 1.2 specifications
- Support for Liberty-based Single Sign-on and Federated Identity protocols
- Support for the SAML 1.0/1.1 specifications

> **See Also:** You can find the Liberty Alliance specifications at `http://www.projectliberty.org/resources/specifications.php`.

11.2 Oracle Liberty 1.1

This section explains how to set up your environment for and use Oracle Liberty 1.1, and describes the classes and interfaces of Oracle Liberty 1.1. It contains the following topics:

- Setting Up Your Oracle Liberty 1.1 Environment
- Overview of Oracle Liberty 1.1 Classes and Interfaces
- The Oracle Liberty SDK 1.1 API Reference
- Example Programs

11.2.1 Setting Up Your Oracle Liberty 1.1 Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME`.

This section explains how to set up your environment for Oracle Liberty 1.1. It contains these topics:

- System Requirements for Oracle Liberty 1.1
- Setting the CLASSPATH Environment Variable

11.2.1.1 System Requirements for Oracle Liberty 1.1

In order to use Oracle Liberty 1.1, your system must have the Java Development Kit (JDK) version 1.5 or higher.

11.2.1.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`
- `osdt_xmlsec.jar`
- `osdt_saml.jar`
- The `org.jaxen_1.1.1.jar` file (Jaxen XPath engine, included with your Oracle XML Security distribution)
- the `osdt_lib_v11.jar` file

11.2.1.2.1 Setting the CLASSPATH on Windows

To set the `CLASSPATH` on Windows:

1. In your Windows **Control Panel**, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click Edit.
5. Add the full path and file names for all of the required jar files to the `CLASSPATH`.

For example, your CLASSPATH might look like this:

```
%CLASSPATH%;%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_xmlsec.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_saml.jar;
%ORACLE_HOME%\modules\org.jaxen_1.1.1.jar;
%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_lib_v11.jar;
```

6. Click **OK**.

11.2.1.2.2 Setting the CLASSPATH on UNIX To set your CLASSPATH on UNIX, set your CLASSPATH environment variable to include the full path and file name of all of the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_xmlsec.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_saml.jar:
$ORACLE_HOME/modules/org.jaxen_1.1.1.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_lib_v11.jar
```

11.2.2 Overview of Oracle Liberty 1.1 Classes and Interfaces

This section introduces some useful classes and interfaces of Oracle Liberty SDK v. 1.1. It contains these topics:

- Core Classes and Interfaces
- Supporting Classes and Interfaces

11.2.2.1 Core Classes and Interfaces

This section describes core classes and interfaces of the Oracle Liberty SDK v. 1.1.

The core classes are:

- The oracle.security.xmlsec.liberty.v11.AuthnRequest Class
- The oracle.security.xmlsec.liberty.v11.AuthnResponse Class
- The oracle.security.xmlsec.liberty.v11.FederationTerminationNotification Class
- The oracle.security.xmlsec.liberty.v11.LogoutRequest Class
- The oracle.security.xmlsec.liberty.v11.LogoutResponse Class
- The oracle.security.xmlsec.liberty.v11.RegisterNameIdentifierRequest Class
- The oracle.security.xmlsec.liberty.v11.RegisterNameIdentifierResponse Class

11.2.2.1.1 The oracle.security.xmlsec.liberty.v11.AuthnRequest Class

This class represents the AuthnRequest element of the Liberty protocol schema.

Example 11–1 shows how to create a new AuthnRequest element and append it to a document.

Example 11–1 Creating an AuthnRequest Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
AuthnRequest authnRequest = new AuthnRequest(doc);
doc.getDocumentElement().appendChild(authnRequest);
```

Example 11–2 shows how to obtain `AuthnRequest` elements from an XML document.

Example 11–2 Obtaining AuthnRequest Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all AuthnRequest elements in the document.
NodeList arList =
    doc.getElementsByTagNameNS(LibertyURI.ns_liberty, "AuthnRequest");
if (arList.getLength() == 0)
    System.err.println("No AuthnRequest elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.liberty.v11.AuthnRequest object and process
for (int s = 0, n = arList.getLength(); s < n; ++s)
{
    AuthnRequest authnRequest =
        new AuthnRequest((Element)arList.item(s));

    // Process AuthnRequest element
    ...
}
```

11.2.2.1.2 The oracle.security.xmlsec.liberty.v11.AuthnResponse Class

This class represents the `AuthnResponse` element of the Liberty protocol schema.

Example 11–3 shows how to create a new `AuthnResponse` element and append it to a document.

Example 11–3 Creating an AuthnResponse Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
AuthnResponse authnResponse = new AuthnResponse(doc);
doc.getDocumentElement().appendChild(authnResponse);
```

Example 11–4 shows how to obtain `AuthnResponse` elements from an XML document.

Example 11–4 Obtaining AuthnResponse elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all AuthnResponse elements in the document.
NodeList arList =
    doc.getElementsByTagNameNS(LibertyURI.ns_liberty, "AuthnResponse");
if (arList.getLength() == 0)
    System.err.println("No AuthnResponse elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.liberty.v11.AuthnResponse object and process
for (int s = 0, n = arList.getLength(); s < n; ++s)
{
    AuthnResponse authnResponse =
        new AuthnResponse((Element)arList.item(s));
    // Process AuthnResponse element
    ...
}
```

11.2.2.1.3 The oracle.security.xmlsec.liberty.v11.FederationTerminationNotification Class

This class represents the `FederationTerminationNotification` element of the Liberty protocol schema.

Example 11–5 shows how to create a new federation termination notification element and append it to a document.

Example 11–5 Creating a FederationTerminationNotification Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
FederationTerminationNotification ftn =
    new FederationTerminationNotification(doc);
doc.getDocumentElement().appendChild(ftn);
```

Example 11–6 shows how to obtain federation termination notification elements from an XML document.

Example 11–6 Obtaining FederationTerminationNotification Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all FederationTerminationNotification elements in the document
 NodeList ftnList = doc.getElementsByTagNameNS(LibertyURI.ns_liberty,
    "FederationTerminationNotification");
if (ftnList.getLength() == 0)
    System.err.println("No FederationTerminationNotification elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.liberty.v11.FederationTerminationNotification
// object and process
for (int s = 0, n = ftnList.getLength(); s < n; ++s)
{
    FederationTerminationNotification ftn =
         new FederationTerminationNotification((Element)ftnList.item(s));

    // Process FederationTerminationNotification element
    ...
}
```

11.2.2.1.4 The oracle.security.xmlsec.liberty.v11.LogoutRequest Class

This class represents the `LogoutRequest` element of the Liberty protocol schema.

Example 11–7 shows how to create a new `LogoutRequest` element and append it to a document.

Example 11–7 Creating a LogoutRequest Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
LogoutRequest lr = new LogoutRequest(doc);
doc.getDocumentElement().appendChild(lr);
```

Example 11–8 shows how to obtain `LogoutRequest` elements from an XML document.

Example 11–8 Obtaining LogoutRequest Elements from an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all LogoutRequest elements in the document.
```

```
NodeList lrList = doc.getElementsByTagNameNS(LibertyURI.ns_liberty,
    "LogoutRequest");
if (lrList.getLength() == 0)
    System.err.println("No LogoutRequest elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.liberty.v11.LogoutRequest
// object and process
for (int s = 0, n = lrList.getLength(); s < n; ++s)
{
    LogoutRequest lr = new LogoutRequest((Element)lrList.item(s));

    // Process LogoutRequest element
    ...
}
```

11.2.2.1.5 The oracle.security.xmlsec.liberty.v11.LogoutResponse Class

This class represents the `LogoutResponse` element of the Liberty protocol schema.

Example 11–9 shows how to create a new `LogoutResponse` element and append it to a document.

Example 11–9 Creating a LogoutResponse Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
LogoutResponse lr = new LogoutResponse(doc);
doc.getDocumentElement().appendChild(lr);
```

Example 11–10 shows how to obtain `LogoutResponse` elements from an XML document.

Example 11–10 Obtaining LogoutResponse elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all LogoutResponse elements in the document.
NodeList lrList =
    doc.getElementsByTagNameNS(LibertyURI.ns_liberty, "LogoutResponse");
if (lrList.getLength() == 0)
    System.err.println("No LogoutResponse elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.liberty.v11.LogoutResponse
// object and process
for (int s = 0, n = lrList.getLength(); s < n; ++s)
{
    LogoutResponse lr = new LogoutResponse((Element)lrList.item(s));

    // Process LogoutResponse element
    ...
}
```

11.2.2.1.6 The oracle.security.xmlsec.liberty.v11.RegisterNameIdentifierRequest Class

This class represents the `RegisterNameIdentifierRequest` element of the Liberty protocol schema.

Example 11–11 shows how to create a new RegisterNameIdentifierRequest element and append it to a document.

Example 11–11 Creating a RegisterNameIdentifierRequest Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
RegisterNameIdentifierRequest rnir =
    new RegisterNameIdentifierRequest(doc);
doc.getDocumentElement().appendChild(rnir);
```

Example 11–12 shows how to obtain RegisterNameIdentifierRequest elements from an XML document.

Example 11–12 Obtaining RegisterNameIdentifierRequest Elements from an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all RegisterNameIdentifierRequest elements in the document
NodeList rnirList = doc.getElementsByTagNameNS(LibertyURI.ns_liberty,
    "RegisterNameIdentifierRequest");
if (rnirList.getLength() == 0)
    System.err.println("No RegisterNameIdentifierRequest elements found.");

// Convert each org.w3c.dom.Node object to an
//oracle.security.xmlsec.liberty.v11.RegisterNameIdentifierRequest
// object and process
for (int s = 0, n = rnirList.getLength(); s < n; ++s)
{
    RegisterNameIdentifierRequest rnir = new
        RegisterNameIdentifierRequest((Element)rnirList.item(s));

    // Process RegisterNameIdentifierRequest element
    ...
}
```

11.2.2.1.7 The oracle.security.xmlsec.liberty.v11.RegisterNameIdentifierResponse Class

This class represents the RegisterNameIdentifierResponse element of the Liberty protocol schema.

Example 11–13 shows how to create a new RegisterNameIdentifierResponse element and append it to a document.

Example 11–13 Creating a RegisterNameIdentifierResponse Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
RegisterNameIdentifierResponse rnir = new RegisterNameIdentifierResponse(doc);
doc.getDocumentElement().appendChild(rnir);
```

Example 11–14 shows how to obtain RegisterNameIdentifierResponse elements from an XML document.

Example 11–14 Obtaining RegisterNameIdentifierResponse Elements from an XML Document

```
Document doc = Instance of org.w3c.dom.Document;
```

```
// Get list of all RegisterNameIdentifierResponse elements in the document
NodeList rnirList = doc.getElementsByTagNameNS(LibertyURI.ns_liberty,
    "RegisterNameIdentifierResponse");
if (rnirList.getLength() == 0)
    System.err.println("No RegisterNameIdentifierResponse elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.liberty.v11.RegisterNameIdentifierResponse
// object and process
for (int s = 0, n = rnirList.getLength(); s < n; ++s)
{
    RegisterNameIdentifierResponse rnir = new
        RegisterNameIdentifierResponse((Element)rnirList.item(s));

    // Process RegisterNameIdentifierResponse element
    ...
}
```

11.2.2.2 Supporting Classes and Interfaces

This section describes supporting classes and interfaces of Oracle Liberty SDK v. 1.1.

The supporting classes and interfaces are:

- The oracle.security.xmlsec.liberty.v11.LibertyInitializer class
- The oracle.security.xmlsec.liberty.v11.LibertyURI interface
- The oracle.security.xmlsec.liberty.v11.ac.AuthenticationContextURI interface
- The oracle.security.xmlsec.util.ac.AuthenticationContextStatement class
- The oracle.security.xmlsec.saml.SAMLURI Interface
- The oracle.security.xmlsec.saml.SAMLMessage class

11.2.2.2.1 The oracle.security.xmlsec.liberty.v11.LibertyInitializer class

The `oracle.security.xmlsec.liberty.v11.LibertyInitializer` class handles load-time initialization and configuration of the Oracle Liberty SDK library. You must call this class's static `initialize()` method before making any calls to the Oracle Liberty SDK API.

11.2.2.2.2 The oracle.security.xmlsec.liberty.v11.LibertyURI interface

The `oracle.security.xmlsec.liberty.v11.LibertyURI` interface defines **URI** string constants for algorithms, namespaces and objects. The following naming convention is used:

- Algorithm URIs begin with "`alg_`".
- Namespace URIs begin with "`ns_`".
- Object type URIs begin with "`obj_`".
- Liberty profile namespace URIs begin with "`prof_`".

11.2.2.2.3 The oracle.security.xmlsec.liberty.v11.ac.AuthenticationContextURI interface

The `oracle.security.xmlsec.liberty.v11.ac.AuthenticationContextURI` interface defines URI string constants for algorithms, namespaces and objects. The following naming convention is used:

- Algorithm URIs begin with "alg_".
- Namespace URIs begin with "ns_".
- Object type URIs begin with "obj_".

11.2.2.2.4 The oracle.security.xmlsec.util.ac.AuthenticationContextStatement class

The oracle.security.xmlsec.util.ac.AuthenticationContextStatement class is an abstract class representing the top-level AuthenticationContextStatement element of the Liberty authentication context schema. Each concrete implementation of this class represents a respective class defined in the Liberty Authentication Context Specification.

11.2.2.2.5 The oracle.security.xmlsec.saml.SAMLURI Interface

The oracle.security.xmlsec.saml.SAMLURI interface defines URI string constants for algorithms, namespaces and objects. The following naming convention is used:

- Action namespace URIs defined in the SAML 1.0 specifications begin with "action_"
- Authentication method namespace URIs defined in the SAML 1.0 specifications begin with "authentication_method_".
- Confirmation method namespace URIs defined in the SAML 1.0 specifications begin with "confirmation_method_".
- Namespace URIs begin with "ns_".

11.2.2.2.6 The oracle.security.xmlsec.saml.SAMLMessage class

The oracle.security.xmlsec.saml.SAMLMessage class is the base class for all the SAML and SAML extension messages that may be signed and contain an XML-DSIG structure.

11.2.3 The Oracle Liberty SDK 1.1 API Reference

The Oracle Liberty SDK version 1.1 API Reference is available at:

Oracle Fusion Middleware Liberty 1.1 Java API Reference for Oracle Security Developer Tools

11.2.4 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html.

11.3 Oracle Liberty 1.2

This section describes the classes and interfaces of Oracle Liberty 1.2, and explains how to set up your environment and use Oracle Liberty 1.2. It contains these sections:

- Setting Up Your Oracle Liberty 1.2 Environment
- Overview of Oracle Liberty 1.2 Classes and Interfaces
- The Oracle Liberty SDK 1.2 API Reference

- Example Programs

11.3.1 Setting Up Your Oracle Liberty 1.2 Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in ORACLE_HOME.

This section explains how to set up your environment for Oracle Liberty 1.2. It contains these topics:

- System Requirements for Oracle Liberty 1.2
- Setting the CLASSPATH Environment Variable

11.3.1.1 System Requirements for Oracle Liberty 1.2

In order to use Oracle Liberty 1.2, your system must have the Java Development Kit (JDK) version 1.5 or higher. Also, make sure that your PATH environment variable includes the Java bin directory.

11.3.1.2 Setting the CLASSPATH Environment Variable

Your CLASSPATH environment variable must contain the full path and file names to all of the required jar and class files. Make sure the following items are included in your CLASSPATH:

- osdt_core.jar
- osdt_cert.jar
- osdt_xmlsec.jar
- osdt_saml.jar
- The org.jaxen_1.1.1.jar file (Jaxen XPath engine, included with your Oracle XML Security distribution)
- osdt_lib_v12.jar

11.3.1.2.1 Setting the CLASSPATH on Windows

To set the CLASSPATH on Windows:

1. In your Windows **Control Panel**, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click Environment Variables.
4. In the User Variables section, click New to add a CLASSPATH environment variable for your user profile. If a CLASSPATH environment variable already exists, select it and click Edit.
5. Add the full path and file names for all of the required jar files to the CLASSPATH.

   For example, your CLASSPATH might look like this:

   ```
   %CLASSPATH%;%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_xmlsec.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_saml.jar;
   %ORACLE_HOME%\modules\org.jaxen_1.1.1.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_lib_v12.jar;
   ```

6. Click OK.

11.3.1.2.2 Setting the `CLASSPATH` on Unix

On Unix, set your `CLASSPATH` environment variable to include the full path and file name of all of the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_xmlsec.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_saml.jar:
$ORACLE_HOME/modules/org.jaxen_1.1.1.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_lib_v12.jar
```

11.3.2 Overview of Oracle Liberty 1.2 Classes and Interfaces

This section introduces some useful classes and interfaces of Oracle Liberty SDK v. 1.2. It contains these topics:

- Core Classes and Interfaces
- Supporting Classes and Interfaces

11.3.2.1 Core Classes and Interfaces

This section describes core classes and interfaces of the Oracle Liberty SDK, v. 1.2.

The core classes are:

- The oracle.security.xmlsec.saml.Assertion class
- The oracle.security.xmlsec.samlp.Request class
- The oracle.security.xmlsec.samlp.Response class
- The oracle.security.xmlsec.liberty.v12.AuthnRequest class
- The oracle.security.xmlsec.liberty.v12.AuthnResponse class
- The oracle.security.xmlsec.liberty.v12.FederationTerminationNotification class
- The oracle.security.xmlsec.liberty.v12.LogoutRequest class
- The oracle.security.xmlsec.liberty.v12.LogoutResponse class
- The oracle.security.xmlsec.liberty.v12.RegisterNameIdentifierRequest class
- The oracle.security.xmlsec.liberty.v12.RegisterNameIdentifierResponse class

11.3.2.1.1 The oracle.security.xmlsec.saml.Assertion class

The `oracle.security.xmlsec.saml.Assertion` class represents the Assertion element of the SAML Assertion schema.

Example 11–15 shows how to create a new assertion element and append it to a document.

Example 11–15 Creating an Assertion element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
Assertion assertion = new Assertion(doc);
doc.getDocumentElement().appendChild(assertion);
```

Example 11–16 shows how to obtain assertion elements from an XML document.

Example 11–16 Obtaining Assertion Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all Assertion elements in the document
NodeList assrtList =
    doc.getElementsByTagNameNS(SAMLURI.ns_saml, "Assertion");
if (assrtList.getLength() == 0)
    System.err.println("No Assertion elements found.");

// Convert each org.w3c.dom.Node object to
// an oracle.security.xmlsec.saml.Assertion
// object and process
for (int s = 0, n = assrtList.getLength(); s < n; ++s)
{
    Assertion assertion = new Assertion((Element)assrtList.item(s));

    // Process Assertion element
    ...
}
```

11.3.2.1.2 The oracle.security.xmlsec.samlp.Request class

The `oracle.security.xmlsec.samlp.Request` class represents the `Request` element of the SAML Protocol schema.

Example 11–17 shows how to create a new `Request` element and append it to a document.

Example 11–17 Creating a Request element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
Request request = new Request(doc);
doc.getDocumentElement().appendChild(request);
```

Example 11–18 shows how to obtain `Request` elements from an XML document.

Example 11–18 Obtaining Request Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all Request elements in the document
NodeList reqList =
    doc.getElementsByTagNameNS(SAMLURI.ns_samlp, "Request");
if (reqList.getLength() == 0)
    System.err.println("No Request elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.samlp.Request
// object and process
for (int s = 0, n = reqList.getLength(); s < n; ++s)
{
    Request request = new Request((Element)reqList.item(s));

    // Process Request element
    ...
}
```

11.3.2.1.3 The oracle.security.xmlsec.samlp.Response class

The `oracle.security.xmlsec.samlp.Response` class represents the `Response` element of the SAML Protocol schema.

Example 11–19 shows how to create a new element and append it to a document.

Example 11–19 Creating a Response Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
Response response = new Response(doc);
doc.getDocumentElement().appendChild(response);
```

Example 11–20 shows how to obtain `Response` elements from an XML document.

Example 11–20 Obtaining Response Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all Response elements in the document
NodeList respList =
    doc.getElementsByTagNameNS(SAMLURI.ns_samlp, "Response");
if (respList.getLength() == 0)
    System.err.println("No Response elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.samlp.Response
// object and process
for (int s = 0, n = respList.getLength(); s < n; ++s)
{
    Response response = new Response((Element)respList.item(s));

    // Process Response element
    ...
}
```

11.3.2.1.4 The oracle.security.xmlsec.liberty.v12.AuthnRequest class

The `oracle.security.xmlsec.liberty.v12.AuthnRequest` class represents the `AuthnRequest` element of the Liberty protocol schema.

Example 11–21 shows how to create a new authorization request element and append it to a document.

Example 11–21 Creating an AuthnRequest Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
AuthnRequest authnRequest = new AuthnRequest(doc);
doc.getDocumentElement().appendChild(authnRequest);
```

Example 11–22 shows how to obtain `AuthnRequest` elements from an XML document.

Example 11–22 Obtaining AuthnRequest Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all AuthnRequest elements in the document
NodeList arList = doc.getElementsByTagNameNS(LibertyURI.ns_liberty,
"AuthnRequest");

if (arList.getLength() == 0)
```

```
    System.err.println("No AuthnRequest elements found.");

// Convert each org.w3c.dom.Node object to
// an oracle.security.xmlsec.liberty.v12.AuthnRequest
// object and process
for (int s = 0, n = arList.getLength(); s < n; ++s)
{
    AuthnRequest authnRequest = new AuthnRequest((Element)arList.item(s));

    // Process AuthnRequest element
    ...
}
```

11.3.2.1.5 The oracle.security.xmlsec.liberty.v12.AuthnResponse class

The `oracle.security.xmlsec.liberty.v12.AuthnResponse` class represents the `AuthnResponse` element of the Liberty protocol schema.

Example 11–23 shows how to create a new authorization response element and append it to a document.

Example 11–23 Creating an AuthnResponse Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
AuthnResponse authnResponse = new AuthnResponse(doc);
doc.getDocumentElement().appendChild(authnResponse);
```

Example 11–24 shows how to obtain `AuthnResponse` elements from an XML document.

Example 11–24 Obtaining AuthnResponse Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all AuthnResponse elements in the document.
NodeList arList =
    doc.getElementsByTagNameNS(LibertyURI.ns_liberty, "AuthnResponse");
if (arList.getLength() == 0)
    System.err.println("No AuthnResponse elements found.");

// Convert each org.w3c.dom.Node object to
// an oracle.security.xmlsec.liberty.v12.AuthnResponse
// object and process
for (int s = 0, n = arList.getLength(); s < n; ++s)
{
    AuthnResponse authnResponse =
        new AuthnResponse((Element)arList.item(s));

    // Process AuthnResponse element
    ...
}
```

11.3.2.1.6 The oracle.security.xmlsec.liberty.v12.FederationTerminationNotification class

The `oracle.security.xmlsec.liberty.v12.FederationTerminationNotification` class represents the `FederationTerminationNotification` element of the Liberty protocol schema.

Example 11–25 shows how to create a new federation termination notification element and append it to a document.

Example 11–25 Creating a DocumentFederationTerminationNotification Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
FederationTerminationNotification ftn =
    new FederationTerminationNotification(doc);
doc.getDocumentElement().appendChild(ftn);
```

Example 11–26 shows how to obtain federation termination notification elements from an XML document.

Example 11–26 Obtaining FederationTerminationNotification Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all FederationTerminationNotification elements in the document
NodeList ftnList = doc.getElementsByTagNameNS(LibertyURI.ns_liberty,
    "FederationTerminationNotification");
if (ftnList.getLength() == 0)
    System.err.println("No FederationTerminationNotification elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.liberty.v12.FederationTerminationNotification
// object and process
for (int s = 0, n = ftnList.getLength(); s < n; ++s)
{
    FederationTerminationNotification ftn = new
        FederationTerminationNotification((Element)ftnList.item(s));

    // Process FederationTerminationNotification element
    ...
}
```

11.3.2.1.7 The oracle.security.xmlsec.liberty.v12.LogoutRequest class

The `oracle.security.xmlsec.liberty.v12.LogoutRequest` class represents the `LogoutRequest` element of the Liberty protocol schema.

Example 11–27 shows how to create a new element and append it to a document.

Example 11–27 Creating a new LogoutRequest Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
LogoutRequest lr = new LogoutRequest(doc);
doc.getDocumentElement().appendChild(lr);
```

Example 11–28 shows how to obtain logout request elements from an XML document.

Example 11–28 Obtaining LogoutRequest Elements from an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all LogoutRequest elements in the document
NodeList lrList =
    doc.getElementsByTagNameNS(LibertyURI.ns_liberty, "LogoutRequest");
if (lrList.getLength() == 0)
```

```
    System.err.println("No LogoutRequest elements found.");

// Convert each org.w3c.dom.Node object to
// an oracle.security.xmlsec.liberty.v12.LogoutRequest
// object and process
for (int s = 0, n = lrList.getLength(); s < n; ++s)
{
    LogoutRequest lr = new LogoutRequest((Element)lrList.item(s));

    // Process LogoutRequest element
    ...
}
```

11.3.2.1.8 The oracle.security.xmlsec.liberty.v12.LogoutResponse class

The `oracle.security.xmlsec.liberty.v12.LogoutResponse` class represents the `LogoutResponse` element of the Liberty protocol schema.

Example 11–29 shows how to create a new logout response element and append it to a document.

Example 11–29 Creating a new LogoutResponse Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
LogoutResponse lr = new LogoutResponse(doc);
doc.getDocumentElement().appendChild(lr);
```

Example 11–30 shows how to obtain logout response elements from an XML document.

Example 11–30 Obtaining LogoutResponse Elements from an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all LogoutResponse elements in the document
NodeList lrList =
    doc.getElementsByTagNameNS(LibertyURI.ns_liberty, "LogoutResponse");
if (lrList.getLength() == 0)
    System.err.println("No LogoutResponse elements found.");

// Convert each org.w3c.dom.Node object to
// an oracle.security.xmlsec.liberty.v12.LogoutResponse
// object and process
for (int s = 0, n = lrList.getLength(); s < n; ++s)
{
    LogoutResponse lr = new LogoutResponse((Element)lrList.item(s));

    // Process LogoutResponse element
    ...
}
```

11.3.2.1.9 The oracle.security.xmlsec.liberty.v12.RegisterNameIdentifierRequest class

The `oracle.security.xmlsec.liberty.v12.RegisterNameIdentifierRequest` class represents the `RegisterNameIdentifierRequest` element of the Liberty protocol schema.

Example 11–31 shows how to create a new `RegisterNameIdentifierRequest` element and append it to a document.

Example 11–31 Creating a new RegisterNameIdentifierRequest Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
RegisterNameIdentifierRequest rnir = new RegisterNameIdentifierRequest(doc);
doc.getDocumentElement().appendChild(rnir);
```

Example 11–32 shows how to obtain `RegisterNameIdentifierRequest` elements from an XML document.

Example 11–32 Obtaining RegisterNameIdentifierRequest Elements from an XML Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all
// RegisterNameIdentifierRequest elements
// in the document
NodeList rnirList =
    doc.getElementsByTagNameNS(LibertyURI.ns_liberty,
    "RegisterNameIdentifierRequest");
if (rnirList.getLength() == 0)
    System.err.println("No RegisterNameIdentifierRequest elements found.");

// Convert each org.w3c.dom.Node object to a
// oracle.security.xmlsec.liberty.v12.RegisterNameIdentifierRequest
// object and process
for (int s = 0, n = rnirList.getLength(); s < n; ++s)
{
    RegisterNameIdentifierRequest rnir =
         new RegisterNameIdentifierRequest((Element)rnirList.item(s));

    // Process RegisterNameIdentifierRequest element
    ...
}
```

11.3.2.1.10 The oracle.security.xmlsec.liberty.v12.RegisterNameIdentifierResponse class

The `oracle.security.xmlsec.liberty.v12.RegisterNameIdentifierResponse` class represents the `RegisterNameIdentifierResponse` element of the Liberty protocol schema.

Example 11–33 shows how to create a new `RegisterNameIdentifierResponse` element and append it to a document.

Example 11–33 Creating a New RegisterNameIdentifierResponse Element and Appending it to a Document

```
Document doc = Instance of org.w3c.dom.Document;
RegisterNameIdentifierResponse rnir =
    new RegisterNameIdentifierResponse(doc);
doc.getDocumentElement().appendChild(rnir);
```

Example 11–34 shows how to obtain `RegisterNameIdentifierResponse` elements from an XML document.

Example 11–34 Obtaining RegisterNameIdentifierResponse Elements from a Document

```
Document doc = Instance of org.w3c.dom.Document;

// Get list of all RegisterNameIdentifierResponse elements in the document
NodeList rnirList =
    doc.getElementsByTagNameNS(LibertyURI.ns_liberty,
        "RegisterNameIdentifierResponse");

if (rnirList.getLength() == 0)
    System.err.println("No RegisterNameIdentifierResponse elements found.");

// Convert each org.w3c.dom.Node object to an
// oracle.security.xmlsec.liberty.v12.RegisterNameIdentifierResponse
// object and process
for (int s = 0, n = rnirList.getLength(); s < n; ++s)
{
    RegisterNameIdentifierResponse rnir = new
        RegisterNameIdentifierResponse((Element)rnirList.item(s));

    // Process RegisterNameIdentifierResponse element
    ...
}
```

11.3.2.2 Supporting Classes and Interfaces

This section describes supporting classes and interfaces of Oracle Liberty SDK v. 1.2:

- The `oracle.security.xmlsec.liberty.v12.LibertyInitializer` class
- The `oracle.security.xmlsec.liberty.v12.LibertyURI` interface
- The `oracle.security.xmlsec.util.ac.AuthenticationContextStatement` class
- The `oracle.security.xmlsec.saml.SAMLInitializer` class
- The `oracle.security.xmlsec.saml.SAMLURI` interface

11.3.2.2.1 The oracle.security.xmlsec.liberty.v12.LibertyInitializer class

This class handles load-time initialization and configuration of the Oracle Liberty SDK 1.2 library. You must call this class's static `initialize()` method before making any calls to the Oracle Liberty SDK 1.2 API.

11.3.2.2.2 The oracle.security.xmlsec.liberty.v12.LibertyURI interface

This interface defines URI string constants for algorithms, namespaces, and objects.

11.3.2.2.3 The oracle.security.xmlsec.util.ac.AuthenticationContextStatement class

This is an abstract class representing the top-level `AuthenticationContextStatement` element of the Liberty authentication context schema. Each concrete implementation of this class represents the respective class defined in the Liberty Authentication Context Specification.

11.3.2.2.4 The oracle.security.xmlsec.saml.SAMLInitializer class

This class handles load-time initialization and configuration of the Oracle SAML library. You should call this class's static `initialize(int major, int minor)` method, for version 1.1, before making any calls to the Oracle SAML Toolkit API for SAML 1.1.

11.3.2.2.5 The oracle.security.xmlsec.saml.SAMLURI Interface

The `oracle.security.xmlsec.saml.SAMLURI` interface defines URI string constants for algorithms, namespaces, and objects. The following naming convention is used:

- Action Namespace URIs defined in the SAML 1.1 specifications begin with "`action_`"
- Authentication Method Namespace URIs defined in the SAML 1.1 specifications begin with "`authentication_method_`"
- Confirmation Method Namespace URIs defined in the SAML 1.1 specifications begin with "`confirmation_method_`"
- Namespace URIs begin with "`ns_`"

11.3.2.2.6 The oracle.security.xmlsec.saml.SAMLMessage Class

`oracle.security.xmlsec.saml.SAMLMessage` is the base class for all the SAML and SAML extension messages that may be signed and contain an XML-DSIG structure.

11.3.3 The Oracle Liberty SDK 1.2 API Reference

The Oracle Liberty SDK version 1.2 API Reference (Javadoc) is available at:

Oracle Fusion Middleware Liberty 1.2 Java API Reference for Oracle Security Developer Tools

11.3.4 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at `http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html`.

12

Oracle XKMS

XKMS (XML Key Management Specification) is a W3C specification for public key management. It provides a convenient way to handle public key infrastructures by enabling developers to write XML transactions for digital signature processing.

This chapter contains these topics:

12.1 Oracle XKMS Features and Benefits

Oracle XKMS is a pure Java solution which consists of a toolkit for locating keys and verifying user identities across businesses and applications. It supports the secure, trusted messaging required for web services, and provides a way to sidestep some of the costs and complexity associated with PKI.

Oracle XKMS provides the following features:

- Simplified access to PKI functionality - by implementing the W3C XKMS Standard, Oracle XKMS combines the simplicity of XML with the robustness of PKI. With this toolkit, developers can easily deploy robust application functionality by deploying secure, lightweight client software.
- Supports complete key/certificate life cycle - Oracle XKMS helps enterprise applications locate, retrieve, and validate signature and encryption keys using lightweight Web Services infrastructure.
- Secures XKMS messages using XML Signatures - requests and responses can be digitally signed using Oracle XML toolkit.
- 100% Java with no native methods
- Works with JAXP 1.1 compliant XML parsers

12.1.1 Oracle XKMS Packages

The Oracle XKMS library contains the following packages:

Table 12–1 Packages in the Oracle XKMS Library

Package	Description
`oracle.security.xmlsec.xkms`	Contains the main XKMS message elements
`oracle.security.xmlsec.xkms.xkiss`	Contains the classes for the Key Information Service Specification
`oracle.security.xmlsec.xkms.xkrss`	Contains the classes for the Key Registration Service Specification
`oracle.security.xmlsec.xkms.util`	Contains constants and utility classes

12.2 Setting Up Your Oracle XKMS Environment

The Oracle Security Developer Tools are installed with Oracle Application Server in `ORACLE_HOME`. This section explains how to set up your environment for Oracle XKMS. It contains these topics:

- System Requirements for Oracle XKMS
- Setting the CLASSPATH Environment Variable

12.2.1 System Requirements for Oracle XKMS

In order to use Oracle XKMS, your system must have the following components installed:

- The Java Development Kit (JDK) version 1.5 or higher
- the Oracle XML Security toolkit

12.2.2 Setting the CLASSPATH Environment Variable

Your `CLASSPATH` environment variable must contain the full path and file names to the required jar and class files. Make sure that the following files are included in your `CLASSPATH`:

- `osdt_core.jar`
- `osdt_cert.jar`
- `osdt_xmlsec.jar`
- `org.jaxen_1.1.1.jar`, which is located in the `$ORACLE_HOME/modules/` directory of the security tools distribution. Oracle XML Security relies on the Jaxen XPath engine for XPath processing.

12.2.2.1 Setting the CLASSPATH on Windows

To set your `CLASSPATH` on Windows:

1. In your Windows Control Panel, select System.
2. In the System Properties dialog, select the Advanced tab.
3. Click **Environment Variables**.
4. In the User Variables section, click **New** to add a `CLASSPATH` environment variable for your user profile. If a `CLASSPATH` environment variable already exists, select it and click **Edit**.

5. Add the full path and file names for all of the required jar and class files to the CLASSPATH.

   For example, your CLASSPATH might look like this:

   ```
   C:%ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_core.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_cert.jar;
   %ORACLE_HOME%\modules\oracle.osdt_11.1.1\osdt_xmlsec.jar;
   %ORACLE_HOME%\modules\org.jaxen_1.1.1.jar;
   ```

6. Click **OK**.

12.2.2.2 Setting the CLASSPATH on UNIX

On UNIX, set your CLASSPATH environment variable to include the full path and file name of all of the required jar and class files. For example:

```
setenv CLASSPATH $CLASSPATH:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_core.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_cert.jar:
$ORACLE_HOME/modules/oracle.osdt_11.1.1/osdt_xmlsec.jar
%ORACLE_HOME%\modules\org.jaxen_1.1.1.jar;
```

12.3 Core Classes and Interfaces

This section provides information and code samples for using the key classes and interfaces of Oracle XKMS. The core classes are:

- oracle.security.xmlsec.xkms.xkiss.LocateRequest
- oracle.security.xmlsec.xkms.xkiss.LocateResult
- oracle.security.xmlsec.xkms.xkiss.ValidateRequest
- oracle.security.xmlsec.xkms.xkiss.ValidateResult
- oracle.security.xmlsec.xkms.xkrss.RecoverRequest
- oracle.security.xmlsec.xkms.xkrss.RecoverResult

12.3.1 oracle.security.xmlsec.xkms.xkiss.LocateRequest

This class represents the XKMS LocateRequest element.

Example 12–1 shows how to create an instance of LocateRequest:

Example 12–1 Creating an Instance of LocateRequest

```
// Parse the XML document containing the dsig:Signature.
Document sigDoc = //Instance of org.w3c.dom.Document;

//Create Query Key Binding
QueryKeyBinding queryKeyBinding = new QueryKeyBinding(sigDoc);
queryKeyBinding.setTimeInstant(new Date());

// Create the xkms:LocateRequest.
LocateRequest loc = new LocateRequest(sigDoc, queryKeyBinding);
```

Client requests of type LocateRequest must include an xkms:RespondWith attribute.

Example 12–2 shows how RespondWith can be added to a LocateRequest:

Example 12–2 Adding RespondWith to a LocateRequest

```
//Add xkms:RespondWith as X.509 Certificate.
loc.addRespondWith(XKMSURI.respondWith_X509Cert);
```

12.3.2 oracle.security.xmlsec.xkms.xkiss.LocateResult

This class represents the `xkms:LocateResult` element.

Example 12–3 shows how to create an instance of `LocateResult`:

Example 12–3 Creating an Instance of LocateResult

```
//Parse the XML document containin the dsig:Signature
Document sigDoc = //Instance of org.w3c.doc.Document;

// Create the xkms:LocateResult
LocateResult locRes = new LocateResult(sigDoc);

//Set ResultMajor to Success.
locRes.setResultCode(XKMSURI.result_major_success, null);
```

If the `LocateRequest` contained a `RespondWith` attribute of `X509Certificate`, use the following code to add an X509 Certificate to the `LocateResult`:

Example 12–4 Adding an X509 Certificate to LocateResult

```
//Creating a signature and adding X509 certificate to the KeyInfo element.
X509Certificate userCert = // Instance of java.security.cert.X509Certificate
XSSignature Sig = XSSignature.newInstance(sigDoc, "MySignature");
XSKeyInfo xsInfo = sig.getKeyInfo();
X509Data xData = xsInfo.createX509Data(userCert);

//Add X509Data to the KeyInfo
xsInfo.addKeyInfoData(xData);

//Set Key Binding and add KeyInfo the the KeyBinding
UnverifiedKeyBinding keyBinding = new UnverifiedKeyBinding(sigDoc);
keyBinding.setKeyInfo(xsInfo);

//Add Key Binding to LocateResult
locRes.addKeyBinding(keyBinding);
```

12.3.3 oracle.security.xmlsec.xkms.xkiss.ValidateRequest

This class represents the XKMS `xkms:ValidateRequest` element.

Example 12–5 shows how to create an instance of `xkms:ValidateRequest`:

Example 12–5 Creating an Instance of ValidateRequest

```
// Parse the XML document containing the dsig:Signature.
Document sigDoc = //Instance of org.w3c.dom.Document;

//Create Query Key Binding
QueryKeyBinding queryKeyBinding = new QueryKeyBinding(sigDoc);
queryKeyBinding.setTimeInstant(new Date());

// Create the xkms:ValidateRequest.
```

```
ValidateRequest validateReq = new ValidateRequest(sigDoc, queryKeyBinding);
```

Requests of type `ValidateRequest` must include an `xkms:RespondWith` attribute. Example 12–6 shows how to add `RespondWith` to a `ValidateRequest`:

Example 12–6 Adding RespondWith to a ValidateRequest

```
//Add xkms:RespondWith as X.509 Certificate.
validateReq.addRespondWith(XKMSURI.respondWith_X509Cert);
```

12.3.4 oracle.security.xmlsec.xkms.xkiss.ValidateResult

This class represents the XKMS `ValidateResult` element.

Example 12–7 shows how to create an instance of `ValidateResult`:

Example 12–7 Creating an Instance of ValidateResult

```
//Parse the XML document containin the dsig:Signature
Document sigDoc = //Instance of org.w3c.doc.Document;

// Create the xkms:ValidateResult
ValidateResult valRes = new ValidateResult(sigDoc);

//Set ResultMajor to Success.
valRes.setResultCode(XKMSURI.result_major_success, null);
```

Use the following code to set a status in response to a `ValidateRequest`:

Example 12–8 Setting a Response Status for a ValidateRequest

```
//Create a status element and add reasons.
Status responseStatus = new Status(sigDoc);
responseStatus.addValidReason(XKMSURI.reasonCode_IssuerTrust);
responseStatus.addValidReason(XKMSURI.reasonCode_RevocationStatus);
responseStatus.addValidReason(XKMSURI.reasonCode_ValidityInterval);
responseStatus.addValidReason(XKMSURI.reasonCode_Signature);

//Create a xkms:KeyBinding to add status and X509Data
XSKeyInfo xsInfo =
    // Instance of oracle.security.xmlsec.dsig.XSKeyInfo,
    // which contains X509Data
KeyBinding keyBinding = new KeyBinding(sigDoc);
keyBinding.setStatus(responseStatus);
keyBinding.setKeyInfo(xsInfo);

// Add the key binding to the ValidateResult.
valRes.addKeyBinding(keyBinding);
```

12.3.5 oracle.security.xmlsec.xkms.xkrss.RecoverRequest

This class represents the XKMS `RecoverRequest` element.

Example 12–9 shows how to create an instance of `RecoverRequest`:

Example 12–9 Creating an Instance of RecoverRequest

```
// Parse the XML document containing the dsig:Signature.
Document sigDoc = //Instance of org.w3c.dom.Document;
```

```
// Create the xkms:RecoverRequest
RecoverRequest recReq = new RecoverRequest(sigDoc);

//Set RespondWith to PrivateKey, so that the RecoverResult
contains the private key.
recReq.addRespondWith(XKMSURI.respondWith_PrivateKey);
```

A `RecoverRequest` must include the `Authentication` and `RecoverKeyBinding` elements. These can be added with the following code:

Example 12–10 Adding Authentication and RecoverKeyBinding to a RecoverRequest

```
//Create an instance of XSSignature.
XSSignature sig =
    //Instance of oracle.security.xmlsec.dsig.XSSignature

//Create an instance of Authentication element.
Authentication auth = new Authentication(sigDoc);

//Set key binding authentication.
auth.setKeyBindingAuthentication(sig);

//Set Authentication for the RecoverRequest.
recReq.setAuthentication(auth);

//Add RecoverKeyBinding to RecoverRequest.
RecoverKeyBinding recKeyBind = new RecoverKeyBinding(sigDoc);

//Add Key Info on the key to be recovered.
XSKeyInfo xsInfo =
    //Instance of oracle.security.xmlsec.dsig.XSKeyInfo
recKeyBind.setKeyInfo(xsInfo);

//Adding status, as known to the key holder, to the KeyBinding
Status keyStatus = new Status(sigDoc);
keyStatus.setStatusValue(XKMSURI.kbs_Indeterminate);
recKeyBind.setStatus(keyStatus);

//Adding RecoverKeyBinding to RecoverRequest.
recReq.setKeyBinding(recKeyBind);
```

12.3.6 oracle.security.xmlsec.xkms.xkrss.RecoverResult

This class represents the `xkms:RecoverResult` element.

Example 12–11 shows how to create an instance of `RecoverResult`:

Example 12–11 Creating an Instance of xkms:RecoverResult

```
// Parse the XML document containing the dsig:Signature.
Document sigDoc = //Instance of org.w3c.dom.Document;

// Create the xkms:RecoverResult
RecoverResult recResult = new RecoverResult(sigDoc);

//Set ResultMajor to Success.
recResult.setResultCode(XKMSURI.result_major_success, null);
```

The KeyBinding needs to be set for a RecoverResult. You can accomplish this with the following code:

Example 12–12 Creating a Key Binding for a RecoverResult

```
//Create a xkms:KeyBinding to add status and X509Data
XSKeyInfo xsInfo =
    //Instance of oracle.security.xmlsec.dsig.XSKeyInfo,
    //which contains X509Data
KeyBinding keyBinding = new KeyBinding(sigDoc);
keyBinding.setKeyInfo(xsInfo);

//Create a status element and add reasons.
//Status is set to Invalid because the service can decide
//to revoke the key binding in the case of recovery.

Status responseStatus = new Status(sigDoc);
responseStatus.addInvalidReason(XKMSURI.reasonCode_IssuerTrust);
responseStatus.addInvalidReason(XKMSURI.reasonCode_RevocationStatus);
responseStatus.addInvalidReason(XKMSURI.reasonCode_ValidityInterval);
responseStatus.addInvalidReason(XKMSURI.reasonCode_Signature);
responseStatus.setStatusValue(XKMSURI.kbs_Invalid);

keyBinding.setStatus(responseStatus);

//Set KeyBinding into RecoverResult
recResult.addKeyBinding(keyBinding);
```

Finally, Example 12–13 shows how to set the recovered PrivateKey into the RecoverResult:

Example 12–13 Setting the Recovered Private Key into RecoverResult

```
//Create an Instance of dsig:XEEncryptedData
XEEncryptedData encryptedData = //Instance of
oracle.security.xmlsec.enc.XEEncryptedData

//Create an instance of oracle.security.xmlsec.xkms.xkrss.PrivateKey
PrivateKey privKey = new PrivateKey(sigDoc);
privKey.setEncryptedData(encryptedData);

//Add PrivateKey to RecoverResult
recResult.setPrivateKey(privKey);
```

12.4 The Oracle XKMS Java API Reference

The Oracle XKMS Java API Reference (Javadoc) is available at:

Oracle Fusion Middleware XKMS Java API Reference for Oracle Security Developer Tools

12.5 Example Programs

For example programs using the Oracle Security Developer Tools, see the Oracle Technology Network Web Site at http://www.oracle.com/technology/sample_code/products/id_mgmt/index.html.

A

References

Table A–1 lists the standards documents and protocols referenced in this document.

Table A–1 Security Standards and Protocols

Document	Reference
[AES-128]	W3C Recommendation XML Encryption: XML Encryption Syntax and Processing, 10 December 2002. See *Block Encryption Algorithms*,http://www.w3.org/2001/04/xmlenc#aes128-cbc and http://www.w3.org/2001/04/xmlenc#kw-aes128
[AES-192]	W3C Recommendation XML Encryption: XML Encryption Syntax and Processing, 10 December 2002. See *Block Encryption Algorithms*,http://www.w3.org/2001/04/xmlenc#aes192-cbc and http://www.w3.org/2001/04/xmlenc#kw-aes192
[AES-256]	W3C Recommendation XML Encryption: XML Encryption Syntax and Processing, 10 December 2002. See *Block Encryption Algorithms*,http://www.w3.org/2001/04/xmlenc#aes256-cbc and http://www.w3.org/2001/04/xmlenc#kw-aes256
Cryptography	Bruce Schneier, *Applied Cryptography: Protocols, Algorithms, and Source Code in C (2nd Edition)*, John Wiley and Sons, 1996.
Cryptography	William Stallings, *Cryptography and Network Security: Principles and Practice (3rd Edition)*, Prentice Hall, 2002.
[DES-EDE]	W3C Recommendation XML Encryption: XML Encryption Syntax and Processing, 10 December 2002. See *Block Encryption Algorithms*,http://www.w3.org/2001/04/xmlenc#aes128-cbc and http://www.w3.org/2001/04/xmlenc#kw-tripledes
Diffie-Hellman Key Agreement	W3C Recommendation XML Encryption: XML Encryption Syntax and Processing, 10 December 2002. See *Diffie-Hellman Key Agreement*, http://www.w3.org/2001/04/xmlenc#dh
[DSA-SHA]	W3C Recommendation XML Encryption: XML Encryption Syntax and Processing, 10 December 2002. See *DSA*, http://www.w3.org/2000/09/xmldsig#dsa-sha1
Liberty Alliance	Liberty Alliance Project ID-FF 1.2 and ID-WSF 2.0 Specifications, http://www.projectliberty.org/resources/specifications.php
[PKCS]	RSA Laboratories, "Public-Key Cryptography Standards (PKCS)", http://www.rsasecurity.com/rsalabs/node.asp?id=2125
[PKCS1]	RSA Laboratories, "PKCS #1: RSA Cryptography Standard", http://www.rsasecurity.com/rsalabs/node.asp?id=2125
[PKCS3]	RSA Laboratories, "PKCS #3: Diffie-Hellman Key Agreement Standard", http://www.rsasecurity.com/rsalabs/node.asp?id=2126
[PKCS5]	RSA Laboratories, "PKCS #5: Password-Based Cryptography Standard", http://www.rsasecurity.com/rsalabs/node.asp?id=2127

Table A–1 (Cont.) Security Standards and Protocols

Document	Reference
[PKCS6]	RSA Laboratories, "PKCS #6: Extended-Certificate Syntax Standard", http://www.rsasecurity.com/rsalabs/node.asp?id=2128
[PKCS7]	RSA Laboratories, "PKCS #7: Cryptographic Message Syntax Standard", http://www.rsasecurity.com/rsalabs/node.asp?id=21299
[PKCS8]	RSA Laboratories, "PKCS #8: Private-Key Information Syntax Standard", http://www.rsasecurity.com/rsalabs/node.asp?id=2130
[PKCS9]	RSA Laboratories, "PKCS #9: Selected Attribute Types", http://www.rsasecurity.com/rsalabs/node.asp?id=2131
[PKCS10]	RSA Laboratories, "PKCS #10: Certification Request Syntax Standard", http://www.rsasecurity.com/rsalabs/node.asp?id=2132
[PKCS11]	RSA Laboratories, "PKCS #11: Cryptographic Token Interface Standard", http://www.rsasecurity.com/rsalabs/node.asp?id=2133
[RFC2311]	S. Dusse, P. Hoffman, B. Ramsdell, L. Lundblade, L. Repka, "S/MIME Version 2 Message Specification". March 1998, http://www.ietf.org/rfc/rfc2311.txt
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Glossary

3DES

See **Triple Data Encryption Standard (3DES)**.

access control item (ACI)

Access control information represents the permissions that various entities or subjects have to perform operations on a given object in the directory. This information is stored in Oracle Internet Directory as user-modifiable operational **attribute**s, each of which is called an access control item (ACI). An ACI determines user access rights to directory data. It contains a set of rules for controlling access to entries (structural access items) and attributes (content access items). Access to both structural and content access items may be granted to one or more users or groups.

access control list (ACL)

A list of resources and the user names of people who are permitted access to those resources within a computer system. In Oracle Internet Directory, an ACL is a list of **access control item (ACI) attribute value**s that is associated with directory objects. The attribute values on that list represent the permissions that various directory user entities (or subjects) have on a given object.

access control policy point (ACP)

A directory entry that contains access control policy information that applies downward to all entries at lower positions in the **directory information tree (DIT)**. This information affects the entry itself and all entries below it. In Oracle Internet Directory, you can create ACPs to apply an access control policy throughout a **subtree** of your directory.

account lockout

A security feature that locks a user account if repeated failed logon attempts occur within a specified amount of time, based on security policy settings. Account lockout occurs in Oracle Single Sign-On when a user submits an account and password combination from any number of workstations more times than is permitted by Oracle Internet Directory. The default lockout period is 24 hours.

ACI

See **access control item (ACI)**.

ACL

See **access control list (ACL)**.

ACP

See **access control policy point (ACP)**.

administrative area

A **subtree** on a directory server whose entries are under the control of a single administrative authority. The designated administrator controls each **entry** in that administrative area, as well as the directory **schema**, **access control list (ACL)**, and **attribute**s for those entries.

Advanced Encryption Standard (AES)

Advanced Encryption Standard (AES) is a **symmetric cryptography** algorithm that is intended to replace **Data Encryption Standard (DES)**. AES is a Federal Information Processing Standard (FIPS) for the encryption of commercial and government data.

advanced replication

See **Oracle Database Advanced Replication**.

advanced symmetric replication (ASR)

See **Oracle Database Advanced Replication**.

AES

See **Advanced Encryption Standard (AES)**.

anonymous authentication

The process by which a directory authenticates a user without requiring a user name and password combination. Each anonymous user then exercises the privileges specified for anonymous users.

API

See **application programming interface (API)**.

application programming interface (API)

A series of software routines and development tools that comprise an interface between a computer application and lower-level services and functions (such as the operating system, device drivers, and other software applications). APIs serve as building blocks for programmers putting together software applications. For example, LDAP-enabled clients access Oracle Internet Directory information through programmatic calls available in the LDAP API.

application service provider

Application Service Providers (ASPs) are third-party entities that manage and distribute software-based services and solutions to customers across a wide area network from a central data center. In essence, ASPs are a way for companies to outsource some or almost all aspects of their information technology needs.

artifact profile

An **authentication** mechanism which transmits data using a compact reference to an **assertion**, called an artifact, instead of sending the full assertion. This **profile** accomodates browsers which handle a limited number of characters.

ASN.1

Abstract Syntax Notation One (ASN.1) is an International Telecommunication Union (ITU) notation used to define the syntax of information data. ASN.1 is used to describe structured information, typically information that is to be conveyed across some communications medium. It is widely used in the specification of Internet protocols.

ASR

See **Oracle Database Advanced Replication**.

assertion

An assertion is a statement used by providers in security domains to exchange information about a subject seeking access to a resource. Identity providers, as well as service providers, exchange assertions about identities to make **authentication** and **authorization** decisions, and to determine and enforce security policies protecting the resource.

asymmetric algorithm

A **cryptographic algorithm** that uses different **key**s for **encryption** and **decryption**.

See also: **public key cryptography**.

asymmetric cryptography

See **public key cryptography**.

attribute

Directory attributes hold a specific data element such as a name, phone number, or job title. Each directory **entry** is comprised of a set of attributes, each of which belongs to an **object class**. Moreover, each attribute has both a *type*, which describes the kind of information in the attribute, and a *value*, which contains the actual data.

attribute configuration file

In an Oracle Directory Integration and Provisioning environment, a file that specifies attributes of interest in a connected directory.

attribute type

Attribute types specify information about a data element, such as the data type, maximum length, and whether it is single-valued or multivalued. The attribute type provides the real-world meaning for a value, and specifies the rules for creating and storing specific pieces of data, such as a name or an e-mail address.

attribute uniqueness

An Oracle Internet Directory feature that ensures that no two specified **attribute**s have the same value. It enables applications synchronizing with the enterprise directory to use attributes as unique keys.

attribute value

Attribute values are the actual data contained within an **attribute** for a particular **entry**. For example, for the attribute type `email`, an attribute value might be `sally.jones@oracle.com`.

authentication

The process of verifying the identity claimed by an entity based on its credentials. Authentication of a user is generally based on something the user knows or has (for example, a password or a certificate).

Authentication of an electronic message involves the use of some kind of system (such as **public key cryptography**) to ensure that a file or message which claims to originate from a given individual or company actually does, and a check based on the contents of a message to ensure that it was not modified in transit.

authentication level

An Oracle Single Sign-On parameter that enables you to specify a particular authentication behavior for an application. You can link this parameter with a specific **authentication plugin**.

authentication plugin

An implementation of a specific authentication method. Oracle Single Sign-On has Java plugins for password authentication, digital certificates, Windows native authentication, and third-party access management.

authorization

The process of granting or denying access to a service or network resource. Most security systems are based on a two step process. The first stage is authentication, in which a user proves his or her identity. The second stage is authorization, in which a user is allowed to access various resources based on his or her identity and the defined **authorization policy**.

authorization policy

Authorization policy describes how access to a protected resource is governed. Policy maps identities and objects to collections of rights according to some system model. For example, a particular authorization policy might state that users can access a sales report only if they belong to the sales group.

basic authentication

An **authentication** protocol supported by most browsers in which a Web server authenticates an entity with an encoded user name and password passed via data transmissions. Basic authentication is sometimes called plaintext authentication because the base-64 encoding can be decoded by anyone with a freely available decoding utility. Note that encoding is not the same as **encryption**.

Basic Encoding Rules (BER)

Basic Encoding Rules (BER) are the standard rules for encoding data units set forth in **ASN.1**. BER is sometimes incorrectly paired with ASN.1, which applies only to the abstract syntax description language, not the encoding technique.

BER

See **Basic Encoding Rules (BER)**.

binding

In networking, binding is the establishment of a logical connection between communicating entities.

In the case of Oracle Internet Directory, binding refers to the process of authenticating to the directory.

The formal set of rules for carrying a **SOAP** message within or on top of another protocol (underlying protocol) for the purpose of exchange is also called a binding.

block cipher

Block ciphers are a type of **symmetric algorithm**. A block cipher encrypts a message by breaking it down into fixed-size blocks (often 64 bits) and encrypting each block with a key. Some well known block ciphers include **Blowfish**, **DES**, and **AES**.

See also: **stream cipher**.

Blowfish

Blowfish is a **symmetric cryptography** algorithm developed by Bruce Schneier in 1993 as a faster replacement for **DES**. It is a **block cipher** using 64-bit blocks and keys of up to 448 bits.

CA

See **Certificate Authority (CA)**.

CA certificate

A **Certificate Authority (CA)** signs all certificates that it issues with its **private key**. The corresponding Certificate Authority’s **public key** is itself contained within a certificate, called a CA Certificate (also referred to as a root certificate). A browser must contain the CA Certificate in its list of trusted root certificates in order to trust messages signed by the CA's private key.

cache

Generally refers to an amount of quickly accessible memory in your computer. However, on the Web it more commonly refers to where the browser stores downloaded files and graphics on the user's computer.

CBC

See **cipher block chaining (CBC)**.

central directory

In an Oracle Directory Integration and Provisioning environment, the directory that acts as the central repository. In an Oracle Directory Integration and Provisioning environment, Oracle Internet Directory is the central directory.

certificate

A certificate is a specially formatted data structure that associates a **public key** with the identity of its owner. A certificate is issued by a **Certificate Authority (CA)**. It contains the name, serial number, expiration dates, and public key of a particular entity. The certificate is digitally signed by the issuing CA so that a recipient can verify that the certificate is real. Most digital certificates conform to the **X.509** standard.

Certificate Authority (CA)

A Certificate Authority (CA) is a trusted third party that issues, renews, and revokes digital **certificate**s. The CA essentially vouches for a entity’s identity, and may delegate the verification of an applicant to a **Registration Authority (RA)**. Some well known Certificate Authorities (CAs) include Digital Signature Trust, Thawte, and VeriSign.

certificate chain

An ordered list of certificates containing one or more pairs of a user **certificate** and its associated **CA certificate**.

certificate management protocol (CMP)

Certificate Management Protocol (CMP) handles all relevant aspects of certificate creation and management. CMP supports interactions between **public key infrastructure (PKI)**) components, such as the **Certificate Authority (CA)**, **Registration Authority (RA)**, and the user or application that is issued a certificate.

certificate request message format (CRMF)

Certificate Request Message Format (CRMF) is a format used for messages related to the life-cycle management of **X.509** certificates, as described in the **RFC** 2511 specification.

certificate revocation list (CRL)

A Certificate Revocation List (CRL) is a list of digital **certificate**s which have been revoked by the **Certificate Authority (CA)** that issued them.

change logs

A database that records changes made to a directory server.

cipher

See **cryptographic algorithm**.

cipher block chaining (CBC)

Cipher block chaining (CBC) is a mode of operation for a **block cipher**. CBC uses what is known as an initialization vector (IV) of a certain length. One of its key characteristics is that it uses a chaining mechanism that causes the decryption of a block of ciphertext to depend on all the preceding ciphertext blocks. As a result, the entire validity of all preceding blocks is contained in the immediately previous ciphertext block.

cipher suite

In **Secure Sockets Layer (SSL)**, a set of authentication, encryption, and data integrity algorithms used for exchanging messages between network nodes. During an SSL handshake, the two nodes negotiate to see which cipher suite they will use when transmitting messages back and forth.

ciphertext

Ciphertext is the result of applying a **cryptographic algorithm** to readable data (plaintext) in order to render the data unreadable by all entities except those in possession of the appropriate **key**.

circle of trust

A trust relationship among a set of identity providers and service providers that allows a **principal** to use a single federated identity and **single sign-on (SSO)** when conducting business transactions with providers within that set.

Businesses federate or affiliate together into circles of trust based on Liberty-enabled technology and on operational agreements that define trust relationships between the businesses.

See also: **federated identity management (FIM)**, **Liberty Alliance**.

claim

A claim is a declaration made by an entity (for example, a name, identity, key, group, and so on).

client SSL certificates

A type of **certificate** used to identify a client machine to a server through **Secure Sockets Layer (SSL)** (client authentication).

cluster

A collection of interconnected usable whole computers that is used as a single computing resource. Hardware clusters provide high availability and scalability.

CMP

See **certificate management protocol (CMP)**.

CMS

See **Cryptographic Message Syntax (CMS)**.

code signing certificates

A type of **certificate** used to identify the entity who signed a Java program, Java Script, or other signed file.

cold backup

In Oracle Internet Directory, this refers to the procedure of adding a new **directory system agent (DSA)** node to an existing replicating system by using the database copy procedure.

concurrency

The ability to handle multiple requests simultaneously. Threads and processes are examples of concurrency mechanisms.

concurrent clients

The total number of clients that have established a session with Oracle Internet Directory.

concurrent operations

The number of operations that are being executed on Oracle Internet Directory from all of the **concurrent clients**. Note that this is not necessarily the same as the concurrent clients, because some of the clients may be keeping their sessions idle.

confidentiality

In cryptography, confidentiality (also known as privacy) is the ability to prevent unauthorized entities from reading data. This is typically achieved through **encryption**.

configset

See **configuration set entry**.

configuration set entry

An Oracle Internet Directory entry holding the configuration parameters for a specific instance of the directory server. Multiple configuration set entries can be stored and referenced at runtime. The configuration set entries are maintained in the subtree specified by the `subConfigsubEntry` attribute of the **directory-specific entry (DSE)**, which itself resides in the associated **directory information base (DIB)** against which the servers are started.

connect descriptor

A specially formatted description of the destination for a network connection. A connect descriptor contains destination service and network route information.

The destination service is indicated by using its service name for the Oracle Database or its Oracle System Identifier (SID) for Oracle release 8.0 or version 7 databases. The network route provides, at a minimum, the location of the listener through use of a network address.

connected directory

In an Oracle Directory Integration and Provisioning environment, an information repository requiring full synchronization of data between Oracle Internet Directory and itself—for example, an Oracle human resources database.

consumer

A directory server that is the destination of replication updates. Sometimes called a slave.

contention

Competition for resources.

context prefix

The **distinguished name (DN)** of the root of a **naming context**.

CRL

See **certificate revocation list (CRL)**.

CRMF

See **certificate request message format (CRMF)**.

cryptographic algorithm

A cryptographic algorithm is a defined sequence of processes to convert readable data (plaintext) to unreadable data (ciphertext) and vice versa. These conversions require some secret knowledge, normally contained in a **key**. Examples of cryptographic algorithms include **DES**, **AES**, **Blowfish**, and **RSA**.

Cryptographic Message Syntax (CMS)

Cryptographic Message Syntax (CMS) is a syntax defined in **RFC** 3369 for signing, digesting, authenticating, and encrypting digital messages.

cryptography

The process of protecting information by transforming it into an unreadable format. The information is encrypted using a **key**, which makes the data unreadable, and is then decrypted later when the information needs to be used again. See also **public key cryptography** and **symmetric cryptography**.

dads.conf

A configuration file for Oracle HTTP Server that is used to configure a **database access descriptor (DAD)**.

DAS

See **Oracle Delegated Administration Services**. (DAS).

Data Encryption Standard (DES)

Data Encryption Standard (DES) is a widely used **symmetric cryptography** algorithm developed in 1974 by IBM. It applies a 56-bit key to each 64-bit block of data. DES and 3DES are typically used as encryption algorithms by **S/MIME**.

data integrity

The guarantee that the contents of the message received were not altered from the contents of the original message sent.

See also: **integrity**.

database access descriptor (DAD)

Database connection information for a particular Oracle Application Server component, such as the Oracle Single Sign-On schema.

decryption

The process of converting the contents of an encrypted message (ciphertext) back into its original readable format (plaintext).

default identity management realm

In a hosted environment, one enterprise—for example, an application service provider—makes Oracle components available to multiple other enterprises and stores information for them. In such hosted environments, the enterprise performing the hosting is called the default identity management realm, and the enterprises that are hosted are each associated with their own identity management realm in the **directory information tree (DIT)**.

default knowledge reference

A **knowledge reference** that is returned when the base object is not in the directory, and the operation is performed in a **naming context** not held locally by the server. A default knowledge reference typically sends the user to a server that has more knowledge about the directory partitioning arrangement.

default realm location

An attribute in the **root Oracle Context** that identifies the root of the **default identity management realm**.

defederation

The act of unlinking a user's account from an **identity provider** or **service provider**.

Delegated Administration Services

See **Oracle Delegated Administration Services**.

delegated administrator

In a hosted environment, one enterprise—for example, an application service provider—makes Oracle components available to multiple other enterprises and stores information for them. In such an environment, a global administrator performs activities that span the entire directory. Other administrators—called delegated administrators—may exercise roles in specific identity management realms, or for specific applications.

DER

See **Distinguished Encoding Rules (DER)**.

DES

See **Data Encryption Standard (DES)**.

DIB

See **directory information base (DIB)**.

Diffie-Hellman

Diffie-Hellman (DH) is a public key cryptography protocol that allows two parties to establish a shared secret over an unsecure communications channel. First published in 1976, it was the first workable public key cryptographic system.

See also: **symmetric algorithm**.

digest

See **message digest**.

digital certificate

See **certificate**.

digital signature

A digital signature is the result of a two-step process applied to a given block of data. First, a **hash function** is applied to the data to obtain a result. Second, that result is encrypted using the signer's **private key**. Digital signatures can be used to ensure integrity, message authentication, and non-repudiation of data. Examples of digital signature algorithms include **DSA** and **RSA**.

Digital Signature Algorithm (DSA)

The Digital Signature Algorithm (DSA) is an **asymmetric algorithm** that is used as part of the Digital Signature Standard (DSS). It cannot be used for encryption, only for digital signatures. The algorithm produces a pair of large numbers that enable the authentication of the signatory, and consequently, the integrity of the data attached. DSA is used both in generating and verifying digital signatures.

directory

See **Oracle Internet Directory**, **Lightweight Directory Access Protocol (LDAP)**, and **X.500**.

directory information base (DIB)

The complete set of all information held in the directory. The DIB consists of entries that are related to each other hierarchically in a **directory information tree (DIT)**.

directory information tree (DIT)

A hierarchical tree-like structure consisting of the **DN**s of the entries.

directory integration and provisioning server

In an Oracle Directory Integration and Provisioning environment, the server that drives the synchronization of data between Oracle Internet Directory and a **connected directory**.

directory integration profile

In an Oracle Directory Integration and Provisioning environment, an entry in Oracle Internet Directory that describes how Oracle Directory Integration and Provisioning communicates with external systems and what is communicated.

Directory Manager

See **Oracle Directory Manager**.

directory naming context

See **naming context**.

directory provisioning profile

A special kind of **directory integration profile** that describes the nature of provisioning-related notifications that Oracle Directory Integration and Provisioning sends to the directory-enabled applications.

directory replication group (DRG)

The directory servers participating in a **replication agreement**.

directory server instance

A discrete invocation of a directory server. Different invocations of a directory server, each started with the same or different configuration set entries and startup flags, are said to be different directory server instances.

directory synchronization profile

A special kind of **directory integration profile** that describes how synchronization is carried out between Oracle Internet Directory and an external system.

directory system agent (DSA)

The **X.500** term for a directory server.

directory-specific entry (DSE)

An entry specific to a directory server. Different directory servers may hold the same **directory information tree (DIT)** name, but have different contents—that is, the contents can be specific to the directory holding it. A DSE is an entry with contents specific to the directory server holding it.

directory user agent (DUA)

The software that accesses a directory service on behalf of the directory user. The directory user may be a person or another software element.

DIS

See **directory integration and provisioning server**.

Distinguished Encoding Rules (DER)

Distinguished Encoding Rules (DER) are a set of rules for encoding **ASN.1** objects in byte-sequences. DER is a special case of **Basic Encoding Rules (BER)**.

distinguished name (DN)

A **X.500** distinguished name (DN) is a unique name for a node in a directory tree. A DN is used to provide a unique name for a person or any other directory entry. A DN is a concatenation of selected **attribute**s from each node in the tree along the path from the root node to the named entry's node. For example, in LDAP notation, the DN for a person named John Smith working at Oracle's US office would be: "cn=John Smith, ou=People, o=Oracle, c=us".

DIT

See **directory information tree (DIT)**.

DN

See **distinguished name (DN)**.

domain

A domain includes the Web site and applications that enable a **principal** to utilize resources. A federated site acts as an **identity provider** (also known as the source domain), a **service provider** (also known as the destination domain), or both.

domain component attribute

The domain component (dc) attribute can be used in constructing a **distinguished name (DN)** from a domain name. For example, using a domain name such as "oracle.com", one could construct a DN beginning with "dc=oracle, dc=com", and then use this DN as the root of its subtree of directory information.

Document Object Model

The Document Object Model (DOM) is an object model for representing an HTML or XML document as a tree structure of nodes.

DRG

See **directory replication group (DRG)**.

DSA

See **Digital Signature Algorithm (DSA)** or **directory system agent (DSA)**.

DSE

See **directory-specific entry (DSE)**.

DTD

See **Document Type Definition (DTD)**.

Document Type Definition (DTD)

A Document Type Definition (DTD) is a document that specifies constraints on the tags and tag sequences that are valid for a given **XML** document. DTDs follow the rules of Simple Generalized Markup Language (SGML), the parent language of XML.

EJB

See **Enterprise Java Bean (EJB)**.

encryption

Encryption is the process of converting plaintext to ciphertext by applying a **cryptographic algorithm**.

encryption certificate

An encryption certificate is a **certificate** containing a **public key** that is used to encrypt electronic messages, files, documents, or data transmission, or to establish or exchange a session key for these same purposes.

end-to-end security

This is a property of message-level security that is established when a message traverses multiple applications within and between business entities and is secure over its full route through and between the business entities.

Enterprise Java Bean (EJB)

Enterprise JavaBeans (EJBs) are a Java API developed by Sun Microsystems that defines a component architecture for multi-tier client/server systems. Because EJB systems are written in Java, they are platform independent. Being object oriented, they can be implemented into existing systems with little or no recompiling and configuring.

Enterprise Manager

See **Oracle Enterprise Manager**.

entry

An entry is a unique record in a directory that describes an object, such as a person. An entry consists of **attribute**s and their associated **attribute value**s, as dictated by the **object class** that describes that entry object. All entries in an LDAP directory structure are uniquely identified through their **distinguished name (DN)**.

export agent

In an Oracle Directory Integration and Provisioning environment, an agent that exports data out of Oracle Internet Directory.

export data file

In an Oracle Directory Integration and Provisioning environment, the file that contains data exported by an **export agent**.

export file

See **export data file**.

external agent

A directory integration agent that is independent of Oracle Directory Integration and Provisioning server. Oracle Directory Integration and Provisioning server does not provide scheduling, mapping, or error handling services for it. An external agent is typically used when a third party metadirectory solution is integrated with Oracle Directory Integration and Provisioning.

external application

Applications that do not delegate authentication to the Oracle Single Sign-On server. Instead, they display HTML login forms that ask for application user names and passwords. At the first login, users can choose to have the Oracle Single Sign-On server retrieve these credentials for them. Thereafter, they are logged in to these applications transparently.

failover

The process of failure recognition and recovery. In an Oracle Application Server Cold Failover Cluster (Identity Management), an application running on one cluster node is transparently migrated to another cluster node. During this migration, clients accessing the service on the cluster see a momentary outage and may need to reconnect once the failover is complete.

fan-out replication

Also called a point-to-point replication, a type of replication in which a supplier replicates directly to a consumer. That consumer can then replicate to one or more other consumers. The replication can be either full or partial.

Federal Information Processing Standards (FIPS)

Federal Information Processing Standards (FIPS) are standards for information processing issued by the US government Department of Commerce's National Institute of Standards and Technology (NIST).

federated identity management (FIM)

The agreements, standards, and technologies that make identity and entitlements portable across autonomous domains. FIM makes it possible for an authenticated user to be recognized and take part in personalized services across multiple domains. It avoids pitfalls of centralized storage of personal information, while allowing users to link identity information between different accounts. Federated identity requires two key components: trust and standards. The trust model of federated identity management is based on **circle of trust**. The standards are defined by the **Liberty Alliance** Project.

federation

See **identity federation**.

filter

A filter is an expression that defines the entries to be returned from a request or search on a directory. Filters are typically expressed as DNs, for example: `cn=susie smith,o=acme,c=us`.

FIM

See **federated identity management (FIM)**.

FIPS

See **Federal Information Processing Standards (FIPS)**.

forced authentication

The act of forcing a user to reauthenticate if he or she has been idle for a preconfigured amount of time. Oracle Single Sign-On enables you to specify a global user inactivity timeout. This feature is intended for installations that have sensitive applications.

GET

An authentication method whereby login credentials are submitted as part of the login URL.

global administrator

In a hosted environment, one enterprise—for example, an application service provider—makes Oracle components available to multiple other enterprises and stores information for them. In such an environment, a global administrator performs activities that span the entire directory.

global unique identifier (GUID)

An identifier generated by the system and inserted into an entry when the entry is added to the directory. In a multimaster replicated environment, the GUID, not the DN, uniquely identifies an entry. The GUID of an entry cannot be modified by a user.

global user inactivity timeout

An optional feature of Oracle Single Sign-On that forces users to reauthenticate if they have been idle for a preconfigured amount of time. The global user inactivity timeout is much shorter than the single sign-out session timeout.

globalization support

Multilanguage support for graphical user interfaces. Oracle Single Sign-On supports 29 languages.

globally unique user ID

A numeric string that uniquely identifies a user. A person may change or add user names, passwords, and distinguished names, but her globally unique user ID always remains the same.

grace login

A login occurring within the specified period before password expiration.

group search base

In the Oracle Internet Directory default **directory information tree (DIT)**, the node in the identity management realm under which all the groups can be found.

guest user

One who is not an anonymous user, and, at the same time, does not have a specific user entry.

GUID

See **global unique identifier (GUID)**.

handshake

A protocol two computers use to initiate a communication session.

hash

A number generated from a string of text with an algorithm. The hash value is substantially smaller than the text itself. Hash numbers are used for security and for faster access to data.

See also: **hash function**.

hash function

In cryptography, a hash function or one-way hash function is an algorithm that produces a given value when applied to a given block of data. The result of a hash function can be used to ensure the integrity of a given block of data. For a hash function to be considered secure, it must be very difficult, given a known data block and a known result, to produce another data block that produces the same result.

Hashed Message Authentication Code (HMAC)

Hashed Message Authentication Code (HMAC) is a hash function technique used to create a secret hash function output. This strengthens existing hash functions such as MD5 and SHA. It is used in transport layer security (TLS).

HMAC

See **Hashed Message Authentication Code (HMAC)**.

HTTP

The Hyper Text Transfer Protocol (HTTP) is the protocol used between a Web browser and a server to request a document and transfer its contents. The specification is maintained and developed by the World Wide Web Consortium.

HTTP Redirect Profile

A **federation** profile which indicates that the requested resource resides under a different URL.

HTTP Server

See **Oracle HTTP Server**.

httpd.conf

The file used to configure **Oracle HTTP Server**.

iASAdmins

The administrative group responsible for user and group management functions in Oracle Application Server. The Oracle Single Sign-On administrator is a member of the group iASAdmins.

identity federation

The linking of two or more accounts a **principal** may hold with one or more identity providers or service providers within a given **circle of trust**.

When users federate the otherwise isolated accounts they have with businesses, known as their local identities, they create a relationship between two entities, an association comprising any number of service providers and identity providers.

See also: **identity provider**, **service provider**.

identity management

The process by which the complete security lifecycle for network entities is managed in an organization. It typically refers to the management of an organization's application users, where steps in the security life cycle include account creation, suspension, privilege modification, and account deletion. The network entities managed may also include devices, processes, applications, or anything else that needs to interact in a networked environment. Entities managed by an identity management process may also include users outside of the organization, for example customers, trading partners, or Web services.

identity management infrastructure database

The database that contains data for Oracle Single Sign-On and Oracle Internet Directory.

identity management realm

A collection of identities, all of which are governed by the same administrative policies. In an enterprise, all employees having access to the intranet may belong to one realm, while all external users who access the public applications of the enterprise may belong to another realm. An identity management realm is represented in the directory by a specific **entry** with a special **object class** associated with it.

identity management realm-specific Oracle Context

An Oracle Context contained in each identity management realm. It stores the following information:

- User naming policy of the identity management realm—that is, how users are named and located.
- Mandatory authentication attributes.
- Location of groups in the identity management realm.
- Privilege assignments for the identity management realm—for example: who has privileges to add more users to the realm.
- Application specific data for that realm including authorizations.

identity provider

One of the three primary roles defined in the **identity federation** protocols supported by Oracle Identity Federation. The other primary roles are **service provider** and **principal**. The identity provider is responsible for managing and authenticating a set of identities within a given **circle of trust**.

A service provider, in turn, provides services or goods to a principal based on the identity provider's authentication of a principal's identity.

Identity providers are service providers offering business incentives so that other service providers affiliate with them. An identity provider typically authenticates and asserts a principal's identity.

import agent

In an Oracle Directory Integration and Provisioning environment, an agent that imports data into Oracle Internet Directory.

import data file

In an Oracle Directory Integration and Provisioning environment, the file containing the data imported by an **import agent**.

infrastructure tier

The Oracle Application Server components responsible for identity management. These components are Oracle Single Sign-On, Oracle Delegated Administration Services, and Oracle Internet Directory.

inherit

When an **object class** has been derived from another class, it also derives, or inherits, many of the characteristics of that other class. Similarly, an attribute subtype inherits the characteristics of its supertype.

instance

See **directory server instance**.

integrity

In cryptography, integrity is the ability to detect if data has been modified by entities that are not authorized to modify it.

Internet Directory

See **Oracle Internet Directory**.

Internet Engineering Task Force (IETF)

The principal body engaged in the development of new Internet standard specifications. It is an international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet.

Internet Message Access Protocol (IMAP)

A protocol allowing a client to access and manipulate electronic mail messages on a server. It permits manipulation of remote message folders, also called mailboxes, in a way that is functionally equivalent to local mailboxes.

J2EE

See **Java 2 Platform, Enterprise Edition (J2EE)**.

Java 2 Platform, Enterprise Edition (J2EE)

Java 2 Platform, Enterprise Edition (J2EE) is an environment for developing and deploying enterprise applications, defined by Sun Microsystems Inc. The J2EE platform consists of a set of services, application programming interfaces (APIs), and protocols that provide the functionality for developing multitiered, Web-based applications.

Java Server Page (JSP)

JavaServer Pages (JSP), a server-side technology, are an extension to the Java servlet technology that was developed by Sun Microsystems. JSPs have dynamic scripting capability that works in tandem with HTML code, separating the page logic from the static elements (the design and display of the page). Embedded in the HTML page, the Java source code and its extensions help make the HTML more functional, being used in dynamic database queries, for example.

JSP

See **Java Server Page (JSP)**.

key

A key is a data structure that contains some secret knowledge necessary to successfully encrypt or decrypt a given block of data. The larger the key, the harder it is to crack a block of encrypted data. For example, a 256-bit key is more secure than a 128-bit key.

key pair

A **public key** and its associated **private key**.

See also: **public/private key pair**.

knowledge reference

The access information (name and address) for a remote **directory system agent (DSA)** and the name of the **directory information tree (DIT)** subtree that the remote DSA holds. Knowledge references are also called referrals.

latency

The time a client has to wait for a given directory operation to complete. Latency can be defined as wasted time. In networking discussions, latency is defined as the travel time of a packet from source to destination.

LDAP

See **Lightweight Directory Access Protocol (LDAP)**.

LDAP connection cache

To improve throughput, the Oracle Single Sign-On server caches and then reuses connections to Oracle Internet Directory.

LDAP Data Interchange Format (LDIF)

A common, text-based format for exchanging directory data between systems. The set of standards for formatting an input file for any of the LDAP command-line utilities.

LDIF

See **LDAP Data Interchange Format (LDIF)**.

legacy application

Older application that cannot be modified to delegate authentication to the Oracle Single Sign-On server. Also known as an **external application**.

Liberty Alliance

The Liberty Alliance Project is a consortium of companies, non-profits, and non-government organizations around the globe. It is committed to developing an open standard for **federated identity management (FIM)** and identity-based Web services supporting current and emerging network devices.

Liberty ID-FF

Liberty Identity Federation Framework (Liberty ID-FF) provides an architecture for Web-based **single sign-on (SSO)** with federated identities.

Lightweight Directory Access Protocol (LDAP)

A set of protocols for accessing information in directories. LDAP supports TCP/IP, which is necessary for any type of Internet access. Its framework of design conventions supports industry-standard directory products, such as Oracle Internet Directory. Because it is a simpler version of the **X.500** standard, LDAP is sometimes called X.500 light.

load balancer

Hardware devices and software that balance connection requests between two or more servers, either due to heavy load or failover. BigIP, Alteon, or Local Director are all popular hardware devices. Oracle Web Cache is an example of load balancing software.

logical host

In an Oracle Application Server Cold Failover Cluster (Identity Management), one or more disk groups and pairs of host names and IP addresses. It is mapped to a physical host in the cluster. This physical host impersonates the host name and IP address of the logical host.

MAC

See **message authentication code (MAC)**.

man-in-the-middle

A security attack characterized by the third-party, surreptitious interception of a message. The third-party, the *man-in-the-middle*, decrypts the message, re-encrypts it (with or without alteration of the original message), and retransmits it to the originally-intended recipient—all without the knowledge of the legitimate sender and receiver. This type of security attack works only in the absence of **authentication**.

mapping rules file

In an Oracle Directory Integration and Provisioning environment, the file that specifies mappings between Oracle Internet Directory attributes and those in a **connected directory**.

master definition site (MDS)

In replication, a master definition site is the Oracle Internet Directory database from which the administrator runs the configuration scripts.

master site

In replication, a master site is any site other than the **master definition site (MDS)** that participates in LDAP replication.

matching rule

In a search or compare operation, determines equality between the attribute value sought and the attribute value stored. For example, matching rules associated with the `telephoneNumber` attribute could cause "(650) 123-4567" to be matched with either "(650) 123-4567" or "6501234567" or both. When you create an **attribute**, you associate a matching rule with it.

MD2

Message Digest Two (MD2) is a message digest **hash function**. The algorithm processes input text and creates a 128-bit **message digest** which is unique to the message and can be used to verify data integrity. MD2 was developed by Ron Rivest for RSA Security and is intended to be used in systems with limited memory, such as smart cards.

MD4

Message Digest Four (MD4) is similar to **MD2** but designed specifically for fast processing in software.

MD5

Message Digest Five (MD5) is a message digest **hash function**. The algorithm processes input text and creates a 128-bit **message digest** which is unique to the message and can be used to verify data integrity. MD5 was developed by Ron Rivest after potential weaknesses were reported in **MD4**. MD5 is similar to MD4 but slower because more manipulation is made to the original data.

MDS

See **master definition site (MDS)**.

message authentication

The process of verifying that a particular message came from a particular entity.

See also: **authentication**.

message authentication code (MAC)

The Message Authentication Code (MAC) is a result of a two-step process applied to a given block of data. First, the result of a **hash function** is obtained. Second, that result is encrypted using a **secret key**. The MAC can be used to authenticate the source of a given block of data.

message digest

The result of a **hash function**.

See also: **hash**.

metadirectory

A directory solution that shares information between all enterprise directories, integrating them into one virtual directory. It centralizes administration, thereby reducing administrative costs. It synchronizes data between directories, thereby ensuring that it is consistent and up-to-date across the enterprise.

middle tier

That portion of a Oracle Single Sign-On instance that consists of the Oracle HTTP Server and OC4J. The Oracle Single Sign-On middle tier is situated between the identity management infrastructure database and the client.

mod_osso

A module on the Oracle HTTP Server that enables applications protected by Oracle Single Sign-On to accept HTTP headers in lieu of a user name and password once the user has logged into the Oracle Single Sign-On server. The values for these headers are stored in the **mod_osso cookie**.

mod_osso cookie

User data stored on the HTTP server. The cookie is created when a user authenticates. When the same user requests another application, the Web server uses the information in the mod_osso cookie to log the user in to the application. This feature speeds server response time.

mod_proxy

A module on the Oracle HTTP Server that makes it possible to use **mod_osso** to enable single sign-on to legacy, or **external application**s.

MTS

See **shared server**.

multimaster replication

Also called peer-to-peer or *n*-way replication, a type of replication that enables multiple sites, acting as equals, to manage groups of replicated data. In a multimaster replication environment, each node is both a supplier and a consumer node, and the entire directory is replicated on each node.

name identifier profile

A **federation** profile which allows a provider to inform it's peers when assigning or updating a name identifier for one of their common users.

naming attribute

The attribute used to compose the RDN of a new user entry created through Oracle Delegated Administration Services or Oracle Internet Directory Java APIs. The default value for this is `cn`.

naming context

A subtree that resides entirely on one server. It must be contiguous, that is, it must begin at an entry that serves as the top of the subtree, and extend downward to either leaf entries or **knowledge reference**s (also called referrals) to subordinate naming contexts. It can range in size from a single entry to the entire **directory information tree (DIT)**.

native agent

In an Oracle Directory Integration and Provisioning environment, an agent that runs under the control of the **directory integration and provisioning server**. It is in contrast to an **external agent**.

net service name

A simple name for a service that resolves to a connect descriptor. Users initiate a connect request by passing a user name and password along with a net service name in a connect string for the service to which they wish to connect, for example:

```
CONNECT username/password@net_service_name
```

Depending on your needs, net service names can be stored in a variety of places, including:

- Local configuration file, `tnsnames.ora`, on each client
- Directory server
- Oracle Names server
- External naming service, such as NDS, NIS or CDS

Net Services

See **Oracle Net Services**.

nickname attribute

The attribute used to uniquely identify a user in the entire directory. The default value for this is `uid`. Applications use this to resolve a simple user name to the complete distinguished name. The user nickname attribute cannot be multi-valued—that is, a given user cannot have multiple nicknames stored under the same attribute name.

non-repudiation

In cryptography, the ability to prove that a given **digital signature** was produced with a given entity's **private key**, and that a message was sent untampered at a given point in time.

OASIS

Organization for the Advancement of Structured Information Standards. OASIS is a worldwide not-for-profit consortium that drives the development, convergence and adoption of e-business standards.

object class

In LDAP, object classes are used to group information. Typically an object class models a real-world object such as a person or a server. Each directory entry belongs to one or more object classes. The object class determines the attributes that make up an entry. One object class can be derived from another, thereby inheriting some of the characteristics of the other class.

OC4J

See **Oracle Containers for J2EE (OC4J)**.

OCA

See **Oracle Certificate Authority**.

OCI

See **Oracle Call Interface (OCI)**.

OCSP

See **Online Certificate Status Protocol (OCSP)**.

OEM

See **Oracle Enterprise Manager**.

OID

See **Oracle Internet Directory**.

OID Control Utility

A command-line tool for issuing run-server and stop-server commands. The commands are interpreted and executed by the **OID Monitor** process.

OID Database Password Utility

The utility used to change the password with which Oracle Internet Directory connects to an Oracle Database.

OID Monitor

The Oracle Internet Directory component that initiates, monitors, and terminates the Oracle Internet Directory Server processes. It also controls the replication server if one is installed, and Oracle Directory Integration and Provisioning Server.

Online Certificate Status Protocol (OCSP)

Online Certificate Status Protocol (OCSP) is one of two common schemes for checking the validity of digital certificates. The other, older method, which OCSP has superseded in some scenarios, is **certificate revocation list (CRL)**. OCSP is specified in **RFC** 2560.

one-way function

A function that is easy to compute in one direction but quite difficult to reverse compute, that is, to compute in the opposite direction.

one-way hash function

A **one-way function** that takes a variable sized input and creates a fixed size output.

See also: **hash function**.

Oracle Application Server Single Sign-On

Oracle Single Sign-On consists of program logic that enables you to log in securely to applications such as expense reports, mail, and benefits. These applications take two forms: **partner application**s and **external application**s. In both cases, you gain access to several applications by authenticating only once.

Oracle Call Interface (OCI)

An application programming interface (API) that enables 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.

Oracle Certificate Authority

Oracle Application Server Certificate Authority is a **Certificate Authority (CA)** for use within your Oracle Application Server environment. OracleAS Certificate Authority uses Oracle Internet Directory as the storage repository for certificates. OracleAS Certificate Authority integration with Oracle Single Sign-On and Oracle Internet Directory provides seamless certificate provisioning mechanisms for applications relying on them. A user provisioned in Oracle Internet Directory and authenticated in Oracle Single Sign-On can choose to request a digital certificate from OracleAS Certificate Authority.

Oracle CMS

Oracle CMS implements the IETF **Cryptographic Message Syntax (CMS)** protocol. CMS defines data protection schemes that allow for secure message envelopes.

Oracle Containers for J2EE (OC4J)

A lightweight, scalable container for **Java 2 Platform, Enterprise Edition (J2EE)**.

Oracle Context

See **identity management realm-specific Oracle Context** and **root Oracle Context**.

Oracle Crypto

Oracle Crypto is a pure Java library that provides core cryptography algorithms.

Oracle Database Advanced Replication

A feature in the Oracle Database that enables database tables to be kept synchronized across two Oracle databases.

Oracle Delegated Administration Services

A set of individual, pre-defined services—called Oracle Delegated Administration Services units—for performing directory operations on behalf of a user. Oracle Internet Directory Self-Service Console makes it easier to develop and deploy administration solutions for both Oracle and third-party applications that use Oracle Internet Directory.

Oracle Directory Integration and Provisioning

A collection of interfaces and services for integrating multiple directories by using Oracle Internet Directory and several associated plug-ins and connectors. A feature of Oracle Internet Directory that enables an enterprise to use an external user repository to authenticate to Oracle products.

Oracle Directory Integration and Provisioning Server

In an Oracle Directory Integration and Provisioning environment, a daemon process that monitors Oracle Internet Directory for change events and takes action based on the information present in the **directory integration profile**.

Oracle Directory Integration Platform

A component of **Oracle Internet Directory**. It is a framework developed to integrate applications around a central LDAP directory like Oracle Internet Directory.

Oracle Directory Manager

A Java-based tool with a graphical user interface for administering Oracle Internet Directory.

Oracle Enterprise Manager

A separate Oracle product that combines a graphical console, agents, common services, and tools to provide an integrated and comprehensive systems management platform for managing Oracle products.

Oracle HTTP Server

Software that processes Web transactions that use the Hypertext Transfer Protocol (HTTP). Oracle uses HTTP software developed by the Apache Group.

Oracle Identity Management

An infrastructure enabling deployments to manage centrally and securely all enterprise identities and their access to various applications in the enterprise.

Oracle Internet Directory

A general purpose directory service that enables retrieval of information about dispersed users and network resources. It combines **Lightweight Directory Access Protocol (LDAP)** Version 3 with the high performance, scalability, robustness, and availability of the Oracle Database.

Oracle Liberty SDK

Oracle Liberty SDK implements the **Liberty Alliance** Project specifications enabling federated single sign-on between third-party Liberty-compliant applications.

Oracle Net Services

The foundation of the Oracle family of networking products, allowing services and their client applications to reside on different computers and communicate. The main function of Oracle Net Services is to establish network sessions and transfer data between a client application and a server. Oracle Net Services is located on each computer in the network. Once a network session is established, Oracle Net Services acts as a data courier for the client and the server.

Oracle PKI certificate usages

Defines Oracle application types that a **certificate** supports.

Oracle PKI SDK

Oracle PKI SDK implements the security protocols that are necessary within **public key infrastructure (PKI)** implementations.

Oracle SAML

Oracle SAML provides a framework for the exchange of security credentials among disparate systems and applications in an XML-based format as outlined in the **OASIS** specification for the **Security Assertions Markup Language (SAML)**.

Oracle Security Engine

Oracle Security Engine extends Oracle Crypto by offering X.509 based certificate management functions. Oracle Security Engine is a superset of Oracle Crypto.

Oracle S/MIME

Oracle S/MIME implements the **Secure/Multipurpose Internet Mail Extension (S/MIME)** specifications from the **Internet Engineering Task Force (IETF)** for secure e-mail.

Oracle Wallet Manager

A Java-based application that security administrators use to manage public-key security credentials on clients and servers.

See also: *Oracle Advanced Security Administrator's Guide*.

Oracle Web Services Security

Oracle Web Services Security provides a framework for authentication and authorization using existing security technologies as outlined in the **OASIS** specification for Web Services Security.

Oracle XML Security

Oracle XML Security implements the W3C specifications for XML Encryption and XML Signature.

OracleAS Portal

An Oracle Single Sign-On **partner application** that provides a mechanism for integrating files, images, applications, and Web sites. The External Applications portlet provides access to external applications.

other information repository

In an Oracle Directory Integration and Provisioning environment, in which Oracle Internet Directory serves as the **central directory**, any information repository except Oracle Internet Directory.

OWM

See **Oracle Wallet Manager**.

partition

A unique, non-overlapping directory naming context that is stored on one directory server.

partner application

An Oracle Application Server application or non-Oracle application that delegates the authentication function to the Oracle Single Sign-On server. This type of application spares users from reauthenticating by accepting **mod_osso** headers.

peer-to-peer replication

Also called multimaster replication or *n*-way replication. A type of replication that enables multiple sites, acting as equals, to manage groups of replicated data. In such a replication environment, each node is both a supplier and a consumer node, and the entire directory is replicated on each node.

PKCS#1

The Public Key Cryptography Standards (PKCS) are specifications produced by RSA Laboratories. PKCS#1 provides recommendations for the implementation of public-key cryptography based on the RSA algorithm, covering the following aspects: cryptographic primitives; encryption schemes; signature schemes; ASN.1 syntax for representing keys and for identifying the schemes.

PKCS#5

The Public Key Cryptography Standards (PKCS) are specifications produced by RSA Laboratories. PKCS#5 provides recommendations for the implementation of password-based cryptography.

PKCS#7

The Public Key Cryptography Standards (PKCS) are specifications produced by RSA Laboratories. PKCS #7 describes general syntax for data that may have cryptography applied to it, such as digital signatures and digital envelopes.

PKCS#8

The Public Key Cryptography Standards (PKCS) are specifications produced by RSA Laboratories. PKCS #8 describes syntax for private key information, including a private key for some public key algorithms and a set of attributes. The standard also describes syntax for encrypted private keys.

PKCS#10

The Public Key Cryptography Standards (PKCS) are specifications produced by RSA Laboratories. PKCS #10 describes syntax for a request for certification of a public key, a name, and possibly a set of attributes.

PKCS#12

The Public Key Cryptography Standards (PKCS) are specifications produced by RSA Laboratories. PKCS #12 describes a transfer syntax for personal identity information, including private keys, certificates, miscellaneous secrets, and extensions. Systems (such as browsers or operating systems) that support this standard allow a user to import, export, and exercise a single set of personal identity information—typically in a format called a **wallet**.

PKI

See **public key infrastructure (PKI)**.

plaintext

Plaintext is readable data prior to a transformation to ciphertext using encryption, or readable data that is the result of a transformation from ciphertext using decryption.

point-to-point replication

Also called fan-out replication is a type of replication in which a supplier replicates directly to a consumer. That consumer can then replicate to one or more other consumers. The replication can be either full or partial.

policy precedence

In Oracle Application Server Certificate Authority (OCA), policies are applied to incoming requests in the order that they are displayed on the main policy page. When the OCA policy processor module parses policies, those that appear toward the top of the policy list are applied to requests first. Those that appear toward the bottom of the list are applied last and take precedence over the others. Only enabled policies are applied to incoming requests.

policy.properties

A multipurpose configuration file for Oracle Single Sign-On that contains basic parameters required by the single sign-on server. Also used to configure advanced features of Oracle Single Sign-On, such as multilevel authentication.

POSIX

Portable Operating System Interface for UNIX. A set of programming interface standards governing how to write application source code so that the applications are portable between operating systems. A series of standards being developed by the **Internet Engineering Task Force (IETF)**.

POST Profile

An **authentication** method whereby login credentials are submitted within the body of the login form.

predicates

In Oracle Application Server Certificate Authority (OCA), a policy predicate is a logical expression that can be applied to a policy to limit how it is applied to incoming certificate requests or revocations. For example, the following predicate expression specifies that the policy in which it appears can have a different effect for requests or revocations from clients with DNs that include "ou=sales,o=acme,c=us":

```
Type=="client" AND DN=="ou=sales,o=acme,c=us"
```

principal

One of the three primary roles defined in the **identity federation** protocols supported by Oracle Identity Federation. The other roles are **identity provider** and **service provider**.

A principal is any entity capable of using a service and capable of acquiring a federated identity. Typically, a principal is a person or user, or a system entity whose identity can be authenticated.

primary node

In an Oracle Application Server Cold Failover Cluster (Identity Management), the cluster node on which the application runs at any given time.

See also: **secondary node**.

private key

A private key is the secret key in a **public/private key pair** used in **public key cryptography**. An entity uses its private key to decrypt data that has been encrypted with its **public key**. The entity can also use its private key to create **digital signature**s. The security of data encrypted with the entity's public key as well as signatures created by the private key depends on the private key remaining secret.

private key cryptography

See **symmetric cryptography**.

profile

See **directory integration profile**.

Project Liberty

See **Liberty Alliance**.

provisioned applications

Applications in an environment where user and group information is centralized in Oracle Internet Directory. These applications are typically interested in changes to that information in Oracle Internet Directory.

provisioning

The process of providing users with access to applications and other resources that may be available in an enterprise environment.

provisioning agent

An application or process that translates Oracle-specific provisioning events to external or third-party application-specific events.

provisioning integration profile

A special kind of **directory integration profile** that describes the nature of provisioning-related notifications that Oracle Directory Integration and Provisioning sends to the directory-enabled applications.

proxy server

A server between a client application, such as a Web browser, and a real server. It intercepts all requests to the real server to see if it can fulfil the requests itself. If not, it forwards the request to the real server. In Oracle Single Sign-On, proxies are used for load balancing and as an extra layer of security.

See also: **load balancer**.

proxy user

A kind of user typically employed in an environment with a middle tier such as a firewall. In such an environment, the end user authenticates to the middle tier. The middle tier then logs into the directory on the end user's behalf. A proxy user has the privilege to switch identities and, once it has logged into the directory, switches to the end user's identity. It then performs operations on the end user's behalf, using the authorization appropriate to that particular end user.

public key

A public key is the non-secret key in a **public/private key pair** used in **public key cryptography**. A public key allows entities to encrypt data that can only then be decrypted with the public key's owner using the corresponding **private key**. A public key can also be used to verify digital signatures created with the corresponding private key.

public key certificate

See **certificate**.

public key cryptography

Public key cryptography (also known as asymmetric cryptography) uses two keys, one public and the other private. These keys are called a key pair. The private key must be kept secret, while the public key can be transmitted to any party. The private key and the public key are mathematically related. A message that is signed by a private key can be verified by the corresponding public key. Similarly, a message encrypted by the public key can be decrypted by the private key. This method ensures privacy because only the owner of the private key can decrypt the message.

public key encryption

The process in which the sender of a message encrypts the message with the public key of the recipient. Upon delivery, the message is decrypted by the recipient using the recipient's private key.

public key infrastructure (PKI)

A public key infrastructure (PKI) is a system that manages the issuing, distribution, and authentication of **public key**s and **private key**s. A PKI typically comprises the following components:

- A **Certificate Authority (CA)** that is responsible for generating, issuing, publishing and revoking digital certificates.
- A **Registration Authority (RA)** that is responsible for verifying the information supplied in requests for certificates made to the CA.
- A directory service where a **certificate** or **certificate revocation list (CRL)** gets published by the CA and where they can be retrieved by relying third parties.
- Relying third parties that use the certificates issued by the CA and the **public key**s contained therein to verify **digital signature**s and encrypt data.

public/private key pair

A mathematically related set of two numbers where one is called the private key and the other is called the public key. Public keys are typically made widely available, while private keys are available only to their owners. Data encrypted with a public key can only be decrypted with its associated private key and vice versa. Data encrypted with a public key cannot be decrypted with the same public key.

RC2

Rivest Cipher Two (RC2) is a 64-bit **block cipher** developed by Ronald Rivest for RSA Security, and was designed as a replacement for **Data Encryption Standard (DES)**.

RC4

Rivest Cipher Four (RC4) is a **stream cipher** developed by Ronald Rivest for RSA Security. RC4 allows variable key lengths up to 1024 bits. RC4 is most commonly used to secure data communications by encrypting traffic between Web sites that use the **Secure Sockets Layer (SSL)** protocol.

RDN

See **relative distinguished name (RDN)**.

readable data

Data prior to a transformation to ciphertext via encryption or data that is the result of a transformation from ciphertext via decryption.

realm

See **identity management realm**.

realm search base

An attribute in the **root Oracle Context** that identifies the entry in the **directory information tree (DIT)** that contains all **identity management realms**. This attribute is used when mapping a simple realm name to the corresponding entry in the directory.

referral

Information that a directory server provides to a client and which points to other servers the client must contact to find the information it is requesting.

See also: **knowledge reference**.

Registration Authority (RA)

The Registration Authority (RA) is responsible for verifying and enrolling users before a certificate is issued by a **Certificate Authority (CA)**. The RA may assign each applicant a relative distinguished value or name for the new certificate applied. The RA does not sign or issue certificates.

registry entry

An entry containing runtime information associated with invocations of Oracle Internet Directory servers, called a **directory server instance**. Registry entries are stored in the directory itself, and remain there until the corresponding directory server instance stops.

relational database

A structured collection of data that stores data in tables consisting of one or more rows, each containing the same set of columns. Oracle makes it very easy to link the data in multiple tables. This is what makes Oracle a relational database management system, or RDBMS. It stores data in two or more tables and enables you to define relationships between the tables. The link is based on one or more fields common to both tables.

relative distinguished name (RDN)

The local, most granular level entry name. It has no other qualifying entry names that would serve to uniquely address the entry. In the example, `cn=Smith,o=acme,c=US`, the RDN is `cn=Smith`.

remote master site (RMS)

In a replicated environment, any site, other than the **master definition site (MDS)**, that participates in **Oracle Database Advanced Replication**.

replica

Each copy of a **naming context** that is contained within a single server.

replication agreement

A special directory entry that represents the replication relationship among the directory servers in a **directory replication group (DRG)**.

response time

The time between the submission of a request and the completion of the response.

RFC

The Internet Request For Comments (or RFC) documents are the written definitions of the protocols and policies of the Internet. The Internet Engineering Task Force (IETF) facilitates the discussion, development, and establishment of new standards. A standard is published using the RFC acronym and a reference number. For example, the official standard for e-mail is RFC 822.

root CA

In a hierarchical **public key infrastructure (PKI)**, the root **Certificate Authority (CA)** is the CA whose **public key** serves as the most trusted datum for a security domain.

root directory specific entry (DSE)

An entry storing operational information about the directory. The information is stored in a number of attributes.

root DSE

See **root directory specific entry (DSE)**.

root Oracle Context

In the Oracle Identity Management infrastructure, the root Oracle Context is an entry in Oracle Internet Directory containing a pointer to the default identity management realm in the infrastructure. It also contains information on how to locate an identity management realm given a simple name of the realm.

RSA

RSA is a **public key cryptography** algorithm named after its inventors (Rivest, Shamir, and Adelman). The RSA algorithm is the most commonly used encryption and authentication algorithm and is included as part of the Web browsers from Netscape and Microsoft, and many other products.

RSAES-OAEP

The RSA Encryption Scheme - Optimal Asymmetric Encryption Padding (RSAES-OAEP) is a public key encryption scheme combining the **RSA** algorithm with the OAEP method. Optimal Asymmetric Encryption Padding (OAEP) is a method for encoding messages developed by Mihir Bellare and Phil Rogaway.

S/MIME

See **Secure/Multipurpose Internet Mail Extension (S/MIME)**.

SAML

See **Security Assertions Markup Language (SAML)**.

SASL

See **Simple Authentication and Security Layer (SASL)**.

scalability

The ability of a system to provide throughput in proportion to, and limited only by, available hardware resources.

schema

The collection of **attribute**s, **object class**es, and their corresponding **matching rule**s.

secondary node

In an Oracle Application Server Cold Failover Cluster (Identity Management), the cluster node to which an application is moved during a failover.

See also: **primary node**.

secret key

A secret key is the **key** used in a **symmetric algorithm**. Since a secret key is used for both encryption and decryption, it must be shared between parties that are transmitting ciphertext to one another but must be kept secret from all unauthorized entities.

secret key cryptography

See **symmetric cryptography**.

Secure Hash Algorithm (SHA)

Secure Hash Algorithm (SHA) is a **hash function** algorithm that produces a 160-bit **message digest** based upon the input. The algorithm is used in the Digital Signature Standard (DSS). With the introduction of the Advanced Encryption Standard (AES) which offers three key sizes: 128, 192 and 256 bits, there has been a need for a companion hash algorithm with a similar level of security. The newer SHA-256, SHA-284 and SHA-512 hash algorithms comply with these enhanced requirements.

Secure Sockets Layer (SSL)

Secure Sockets Layer (SSL) is a protocol designed by Netscape Communications to enable encrypted, authenticated communications across networks (such as the Internet). SSL uses the **public key encryption** system from RSA, which also includes the use of a digital certificate. SSL provides three elements of secure communications: **confidentiality**, **authentication**, and **integrity**.

SSL has evolved into **Transport Layer Security (TLS)**. TLS and SSL are not interoperable. However, a message sent with TLS can be handled by a client that handles SSL.

Secure/Multipurpose Internet Mail Extension (S/MIME)

Secure/Multipurpose Internet Mail Extension (S/MIME) is an Internet Engineering Task Force (IETF) standard for securing MIME data through the use of **digital signature**s and **encryption**.

Security Assertions Markup Language (SAML)

An **XML**-based framework which defines mechanisms for exchanging security information about a subject by making assertions about the subject that are used to make access control decisions. SAML enables the exchange of **authentication** and **authorization** information between identity providers and service providers who otherwise may not be able to interoperate.

SAML 2.0 is a major revision of the standard which updates SAML 1.1 and combines input from both Shibboleth and **Liberty ID-FF** specifications. A key aspect of SAML 2.0 is the ability for two sites to establish and maintain an identifier for a user, with that user's cooperation. Additional features include privacy mechanisms and support for global logout.

security token

In the Liberty protocol, refers to a set of security information that represents and substantiates a claim.

server certificate

A **certificate** that attests to the identity of an organization that uses a secure Web server to serve data. A server certificate must be associated with a **public/private key pair** issued by a mutually trusted **Certificate Authority (CA)**. Server certificates are required for secure communications between a browser and a Web server.

service provider

One of the three primary roles defined in the **identity federation** protocols supported by Oracle Identity Federation. The other roles are **identity provider** and **principal**.

A service provider, which is the relying party in SAML, provides services or goods to a principal while relying on an identity provider to authenticate the principal's identity.

service time

The time between the initiation of a request and the completion of the response to the request.

session key

A **secret key** that is used for the duration of one message or communication session.

SGA

See **System Global Area (SGA)**.

SHA

See **Secure Hash Algorithm (SHA)**.

shared server

A server that is configured to allow many user processes to share very few server processes, so the number of users that can be supported is increased. With shared server configuration, many user processes connect to a dispatcher. The dispatcher directs multiple incoming network session requests to a common queue. An idle shared server process from a shared pool of server processes picks up a request from the queue. This means a small pool of server processes can server a large amount of clients. Contrast with dedicated server.

sibling

An entry that has the same parent as one or more other entries.

Signed Public Key And Challenge (SPKAC)

Signed Public Key And Challenge (SPKAC) is a proprietary protocol used by the Netscape Navigator browser to request certificates.

simple authentication

The process by which the client identifies itself to the server by means of a DN and a password which are not encrypted when sent over the network. In the simple authentication option, the server verifies that the DN and password sent by the client match the DN and password stored in the directory.

Simple Authentication and Security Layer (SASL)

Simple Authentication and Security Layer (SASL) is a method for adding **authentication** and **authorization** capabilities to application protocols. SASL provides a security layer between the protocol and the connection, so that users can be authenticated to a server. A security layer can also be negotiated to protect subsequent protocol interactions.

Simple Object Access Protocol (SOAP)

Simple Object Access Protocol (SOAP) is an **XML**-based protocol that defines a framework for exchanging messages between systems over the Internet. A common protocol for Web Services, SOAP is used with transport protocols such as HTTP and FTP. A SOAP message consists of three parts — an envelope that describes the message and how to process it, a set of encoding rules for expressing instances of application-defined datatypes, and a convention for representing remote procedure calls and responses.

single key-pair wallet

A **PKCS#12**-format wallet that contains a single user **certificate** and its associated **private key**. The **public key** is imbedded in the certificate.

single sign-off

The process by which you terminate an Oracle Single Sign-On session and log out of all active partner applications simultaneously. You can do this by logging out of the application that you are working in.

single sign-on (SSO)

In a federated environment, single sign-on enables users to sign on once with a member of a federated group of identity providers and service providers, and later use resources available from members witout needing to sign on again.

single sign-on SDK

Legacy APIs to enable Oracle Single Sign-On partner applications for single sign-on. The SDK consists of PL/SQL and Java APIs as well as sample code that demonstrates how these APIs are implemented. This SDK is now deprecated and **mod_osso** is used instead.

single sign-on server

Program logic that enables users to log in securely to single sign-on applications such as expense reports, mail, and benefits.

SLAPD

Standalone LDAP daemon. An LDAP directory server service that is responsible for most functions of a directory except replication.

slave

See **consumer**.

smart knowledge reference

A **knowledge reference** that is returned when the knowledge reference entry is in the scope of the search. It points the user to the server that stores the requested information.

SOAP

See **Simple Object Access Protocol (SOAP)**.

specific administrative area

Administrative areas control:

- Subschema administration
- Access control administration
- Collective attribute administration

A *specific* administrative area controls one of these aspects of administration. A specific administrative area is part of an autonomous administrative area.

SPKAC

See **Signed Public Key And Challenge (SPKAC)**.

sponsor node

In replication, the node that is used to provide initial data to a new node.

SSL

See **Secure Sockets Layer (SSL)**.

SSO

See **single sign-on (SSO)**.

stream cipher

Stream ciphers are a type of **symmetric algorithm**. A stream cipher encrypts in small units, often a bit or a byte at a time, and implements some form of feedback mechanism so that the key is constantly changing. **RC4** is an example of a stream cipher.

See also: **block cipher**.

subACLSubentry

A specific type of **subentry** that contains **access control list (ACL)** information.

subclass

An object class derived from another object class. The object class from which it is derived is called its **superclass**.

subentry

A type of entry containing information applicable to a group of entries in a subtree. The information can be of these types:

- Access control policy points
- Schema rules
- Collective attributes

Subentries are located immediately below the root of an administrative area.

subordinate CA

In a hierarchical **public key infrastructure (PKI)**, the subordinate **Certificate Authority (CA)** is a CA whose certificate signature key is certified by another CA, and whose activities are constrained by that other CA.

subordinate reference

A **knowledge reference** pointing downward in the **directory information tree (DIT)** to a **naming context** that starts immediately below an entry

subschema DN

The list of **directory information tree (DIT)** areas having independent **schema** definitions.

subSchemaSubentry

A specific type of **subentry** containing **schema** information.

subtree

A section of a directory hierarchy, which is also called a **directory information tree (DIT)**. The subtree typically starts at a particular directory node and includes all subdirectories and objects below that node in the directory hierarchy.

subtype

An attribute with one or more options, in contrast to that same attribute without the options. For example, a `commonName` (`cn`) attribute with American English as an option is a subtype of the `commonName` (`cn`) attribute without that option. Conversely, the `commonName` (`cn`) attribute without an option is the **supertype** of the same attribute with an option.

success URL

When using Oracle Single Sign-On, the URL to the routine responsible for establishing the session and session cookies for an application.

super user

A special directory administrator who typically has full access to directory information.

superclass

The **object class** from which another object class is derived. For example, the object class `person` is the superclass of the object class `organizationalPerson`. The latter, namely, `organizationalPerson`, is a **subclass** of `person` and inherits the attributes contained in `person`.

superior reference

A **knowledge reference** pointing upward to a **directory system agent (DSA)** that holds a naming context higher in the **directory information tree (DIT)** than all the naming contexts held by the referencing DSA.

supertype

An attribute without options, in contrast to the same attribute with one or more options. For example, the `commonName` (`cn`) attribute without an option is the supertype of the same attribute with an option. Conversely, a `commonName` (`cn`) attribute with American English as an option is a **subtype** of the `commonName` (`cn`) attribute without that option.

supplier

In replication, the server that holds the master copy of the **naming context**. It supplies updates from the master copy to the **consumer** server.

symmetric algorithm

A symmetric algorithm is a cryptographic algorithm that uses the same key for encryption and decryption. There are essentially two types of symmetric (or secret key) algorithms — **stream cipher**s and **block cipher**s.

symmetric cryptography

Symmetric cryptography (or shared secret cryptography) systems use the same key to encipher and decipher data. The problem with symmetric cryptography is ensuring a secure method by which the sender and recipient can agree on the secret key. If a third party were to intercept the secret key in transit, they could then use it to decipher anything it was used to encipher. Symmetric cryptography is usually faster than asymmetric cryptography, and is often used when large quantities of data need to be exchanged. **DES**, **RC2**, and **RC4** are examples of symmetric cryptography algorithms.

symmetric key

See **secret key**.

System Global Area (SGA)

A group of shared memory structures that contain data and control information for one Oracle database instance. If multiple users are concurrently connected to the same instance, the data in the instance SGA is shared among the users. Consequently, the SGA is sometimes referred to as the "shared global area." The combination of the background processes and memory buffers is called an Oracle instance.

system operational attribute

An attribute holding information that pertains to the operation of the directory itself. Some operational information is specified by the directory to control the server, for example, the time stamp for an entry. Other operational information, such as access information, is defined by administrators and is used by the directory program in its processing.

think time

The time the user is not engaged in actual use of the processor.

third-party access management system

Non-Oracle single sign-on system that can be modified to use Oracle Single Sign-On to gain access to Oracle Application Server applications.

throughput

The number of requests processed byOracle Internet Directory for each unit of time. This is typically represented as "operations per second."

Time Stamp Protocol (TSP)

Time Stamp Protocol (TSP), as specified in RFC 3161, defines the participating entities, the message formats, and the transport protocol involved in time stamping a digital message. In a TSP system, a trusted third-party Time Stamp Authority (TSA) issues time stamps for messages.

TLS

See **Transport Layer Security (TLS)**.

transformation

The process of mapping data from its source form to a derived form. Typical transformations include **XML canonicalization (C14N)**, XPath, Base64 and XSLT.

Transport Layer Security (TLS)

A protocol providing communications privacy over the Internet. The protocol enables client/server applications to communicate in a way that prevents eavesdropping, tampering, or message forgery.

Triple Data Encryption Standard (3DES)

Triple Data Encryption Standard (3DES) is based on the **Data Encryption Standard (DES)** algorithm developed by IBM in 1974, and was adopted as a national standard in 1977. 3DES uses three 64-bit long keys (overall key length is 192 bits, although actual key length is 56 bits). Data is encrypted with the first key, decrypted with the second key, and finally encrypted again with the third key. This makes 3DES three times slower than standard DES but also three times more secure.

trusted certificate

A third party identity that is qualified with a level of trust. The trust is used when an identity is being validated as the entity it claims to be. Typically, trusted certificates come from a **Certificate Authority (CA)** you trust to issue user certificates.

trustpoint

See **trusted certificate**.

TSP

See **Time Stamp Protocol (TSP)**.

Unicode

A type of universal character set, a collection of 64K characters encoded in a 16-bit space. It encodes nearly every character in just about every existing character set standard, covering most written scripts used in the world. It is owned and defined by Unicode Inc. Unicode is canonical encoding which means its value can be passed around in different locales. But it does not guarantee a round-trip conversion between it and every Oracle character set without information loss.

UNIX Crypt

The UNIX encryption algorithm.

URI

Uniform Resource Identifier (URI). A way to identify any point of content on the Web, whether it be a page of text, a video or sound clip, a still or animated image, or a program. The most common form of URI is the Web page address, which is a particular form or subset of URI called a **URL**.

URL

Uniform Resource Locator (URL). The address of a file accessible on the Internet. The file can be a text file, HTML page, image file, a program, or any other file supported by HTTP. The URL contains the name of the protocol required to access the resource, a domain name that identifies a specific computer on the Internet, and a hierarchical description of the file location on the computer.

URLC token

The Oracle Single Sign-On code that passes authenticated user information to the **partner application**. The partner application uses this information to construct the session cookie.

user name mapping module

A Oracle Single Sign-On Java module that maps a user **certificate** to the user's nickname. The nickname is then passed to an authentication module, which uses this nickname to retrieve the user's certificate from the directory.

user search base

In the Oracle Internet Directory default **directory information tree (DIT)**, the node in the identity management realm under which all the users are placed.

UTC (Coordinated Universal Time)

The standard time common to every place in the world. Formerly and still widely called Greenwich Mean Time (GMT) and also World Time, UTC nominally reflects the mean solar time along the Earth's prime meridian. UTC is indicated by a z at the end of the value, for example, 200011281010z.

UTF-8

A variable-width 8-bit encoding of **Unicode** that uses sequences of 1, 2, 3, or 4 bytes for each character. Characters from 0-127 (the 7-bit ASCII characters) are encoded with one byte, characters from 128-2047 require two bytes, characters from 2048-65535 require three bytes, and characters beyond 65535 require four bytes. The Oracle character set name for this is AL32UTF8 (for the Unicode 3.1 standard).

UTF-16

16-bit encoding of **Unicode**.The Latin-1 characters are the first 256 code points in this standard.

verification

Verification is the process of ensuring that a given **digital signature** is valid, given the **public key** that corresponds to the **private key** purported to create the signature and the data block to which the signature purportedly applies.

virtual host

A single physical Web server machine that is hosting one or more Web sites or domains, or a server that is acting as a proxy to other machines (accepts incoming requests and reroutes them to the appropriate server).

In the case of Oracle Single Sign-On, virtual hosts are used for load balancing between two or more Oracle Single Sign-On servers. They also provide an extra layer of security.

virtual host name

In an Oracle Application Server Cold Failover Cluster (Identity Management), the host name corresponding to a particular virtual IP address.

virtual IP address

In an Oracle Application Server Cold Failover Cluster (Identity Management), each physical node has its own physical IP address and physical host name. To present a single system image to the outside world, the cluster uses a dynamic IP address that can be moved to any physical node in the cluster. This is called the virtual IP address.

wait time

The time between the submission of the request and initiation of the response.

wallet

An abstraction used to store and manage security credentials for an individual entity. It implements the storage and retrieval of credentials for use with various cryptographic services. A wallet resource locator (WRL) provides all the necessary information to locate the wallet.

Wallet Manager

See **Oracle Wallet Manager**.

Web service

A Web service is application or business logic that is accessible using standard Internet protocols, such as **HTTP**, **XML**, and **SOAP**. Web Services combine the best aspects of component-based development and the World Wide Web. Like components, Web Services represent black-box functionality that can be used and reused without regard to how the service is implemented.

Web Services Description Language (WSDL)

Web Services Description Language (WSDL) is the standard format for describing a Web service using **XML**. A WSDL definition describes how to access a Web service and what operations it will perform.

WSDL

See **Web Services Description Language (WSDL)**.

WS-Federation

Web Services Federation Language (WS-Federation) is a specification developed by Microsoft, IBM, BEA, VeriSign, and RSA Security. It defines mechanisms to allow **federation** between entities using different or like mechanisms by allowing and brokering trust of identities, attributes, and authentication between participating **Web service**s.

See also: **Liberty Alliance**.

X.500

X.500 is a standard from the International Telecommunication Union (ITU) that defines how global directories should be structured. X.500 directories are hierarchical with different levels for each category of information, such as country, state, and city.

X.509

X.509 is the most widely used standard for defining digital certificates. A standard from the International Telecommunication Union (ITU), for hierarchical directories with authentication services, used in many **public key infrastructure (PKI)** implementations.

XKMS

The XML Key Management Specification (XKMS), developed by the World Wide Web Consortium (W3C), specifies protocols for distributing and registering public keys. XKMS comprises two parts: the XML Key Information Service Specification (X-KISS), which defines a protocol for a Trust service that resolves public key information; and the XML Key Registration Service Specification (X-KRSS), which defines a protocol for a web service that accepts registration of public key information.

XML

Extensible Markup Language (XML) is a specification developed by the World Wide Web Consortium (W3C). XML is a pared-down version of Standard Generalized Mark-Up Language (SGML), designed especially for Web documents. XML is a metalanguage (a way to define tag sets) that allows developers to define their own customized markup language for many classes of documents.

XML canonicalization (C14N)

This is a process by which two logically equivalent XML documents can be resolved to the same physical representation. This has significance for digital signatures because a signature can only verify against the same physical representation of the data against which it was originally computed. For more information, see the W3C's XML Canonicalization specification.

XML digital signature

An XML structure that contains both the signature value and information about the signed document.

XML encryption

The process of encrypting data and rendering the result in XML format. The resulting data structure, known as XMLEncryptedData, contains the data or a reference to the data.

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