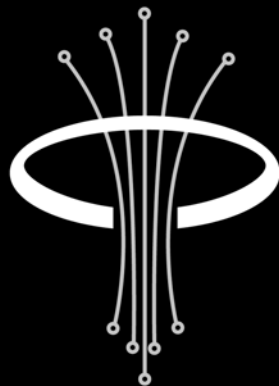


OSGi Service Platform Service Compendium

The OSGi Alliance

**Release 4
August 2005**



OSGiTM
Alliance

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1 Introduction

This compendium contains the specifications of all OSGi services.

1.1 Reader Level

This specification is written for the following audiences:

- Application developers
- Framework and system service developers (system developers)
- Architects

This specification assumes that the reader has at least one year of practical experience in writing Java programs. Experience with embedded systems and server-environments is a plus. Application developers must be aware that the OSGi environment is significantly more dynamic than traditional desktop or server environments.

System developers require a *very* deep understanding of Java. At least three years of Java coding experience in a system environment is recommended. A Framework implementation will use areas of Java that are not normally encountered in traditional applications. Detailed understanding is required of class loaders, garbage collection, Java 2 security, and Java native library loading.

Architects should focus on the introduction of each subject. This introduction contains a general overview of the subject, the requirements that influenced its design, and a short description of its operation as well as the entities that are used. The introductory sections require knowledge of Java concepts like classes and interfaces, but should not require coding experience.

Most of these specifications are equally applicable to application developers and system developers.

1.2 Version Information

This document specifies OSGi Service Platform Release 4. This specification is backward compatible to releases 3.

Components in this specification have their own specification version, independent of the OSGi Service Platform, Release 4 specification. The following table summarizes the packages and specification versions for the different subjects.

Table 1 Packages and versions

Item	Package	Version
101 Log Service Specification	org.osgi.service.log	Version 1.3
102 Http Service Specification	org.osgi.service.http	Version 1.2
103 Device Access Specification	org.osgi.service.device	Version 1.1

Table 1 Packages and versions

Item	Package	Version
104 Configuration Admin Service Specification	org.osgi.service.cm	Version 1.2
105 Metatype Service Specification	org.osgi.service.metatype	Version 1.1
106 Preferences Service Specification	org.osgi.service.prefs	Version 1.1
107 User Admin Service Specification	org.osgi.service.useradmin	Version 1.1
108 Wire Admin Service Specification	org.osgi.service.wireadmin	Version 1.0
109 IO Connector Service Specification	org.osgi.service.io	Version 1.0
110 Initial Provisioning	org.osgi.service.provisioning	Version 1.1
111 UPnP™ Device Service Specification	org.osgi.service.upnp	Version 1.1
112 Declarative Services Specification	org.osgi.service.component	Version 1.0
113 Event Admin Service Specification	org.osgi.service.event	Version 1.0
701 Service Tracker Specification	org.osgi.util.tracker	Version 1.3
702 XML Parser Service Specification	org.osgi.util.xml	Version 1.0
703 Position Specification	org.osgi.util.position	Version 1.0
704 Measurement and State Specification	org.osgi.util.measurement	Version 1.0
999 Execution Environment Specification		Version 1.1

When a component is represented in a bundle, a version attribute is needed in the declaration of the Import-Package or Export-Package manifest headers.

1.3 References

- [1] Bradner, S., *Key words for use in RFCs to Indicate Requirement Levels*
<http://www.ietf.org/rfc/rfc2119.txt>, March 1997.
- [2] *OSGi Service Gateway Specification 1.0*
http://www.osgi.org/resources/spec_download.asp
- [3] *OSGi Service Platform, Release 2, October 2001*
http://www.osgi.org/resources/spec_download.asp
- [4] *OSGi Service Platform, Release 3, March 2003*
http://www.osgi.org/resources/spec_download.asp

101 Log Service Specification

Version 1.3

101.1 Introduction

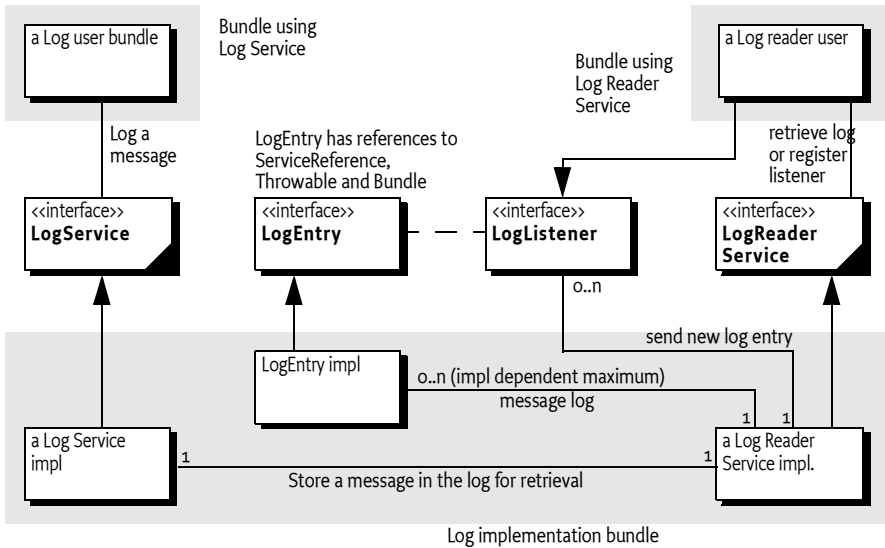
The Log Service provides a general purpose message logger for the OSGi Service Platform. It consists of two services, one for logging information and another for retrieving current or previously recorded log information.

This specification defines the methods and semantics of interfaces which bundle developers can use to log entries and to retrieve log entries.

Bundles can use the Log Service to log information for the Operator. Other bundles, oriented toward management of the environment, can use the Log Reader Service to retrieve Log Entry objects that were recorded recently or to receive Log Entry objects as they are logged by other bundles.

101.1.1 Entities

- *LogService* – The service interface that allows a bundle to log information, including a message, a level, an exception, a *ServiceReference* object, and a *Bundle* object.
- *LogEntry* – An interface that allows access to a log entry in the log. It includes all the information that can be logged through the Log Service and a time stamp.
- *LogReaderService* – A service interface that allows access to a list of recent *LogEntry* objects, and allows the registration of a *LogListener* object that receives *LogEntry* objects as they are created.
- *LogListener* – The interface for the listener to *LogEntry* objects. Must be registered with the Log Reader Service.

Figure 1 Log Service Class Diagram *org.osgi.service.log* package

101.2 The Log Service Interface

The *LogService* interface allows bundle developers to log messages that can be distributed to other bundles, which in turn can forward the logged entries to a file system, remote system, or some other destination.

The *LogService* interface allows the bundle developer to:

- Specify a message and/or exception to be logged.
- Supply a log level representing the severity of the message being logged. This should be one of the levels defined in the *LogService* interface but it may be any integer that is interpreted in a user-defined way.
- Specify the Service associated with the log requests.

By obtaining a *LogService* object from the Framework service registry, a bundle can start logging messages to the *LogService* object by calling one of the *LogService* methods. A Log Service object can log any message, but it is primarily intended for reporting events and error conditions.

The *LogService* interface defines these methods for logging messages:

- *log(int, String)* – This method logs a simple message at a given log level.
- *log(int, String, Throwable)* – This method logs a message with an exception at a given log level.
- *log(ServiceReference, int, String)* – This method logs a message associated with a specific service.
- *log(ServiceReference, int, String, Throwable)* – This method logs a message with an exception associated with a specific service.

While it is possible for a bundle to call one of the log methods without providing a *ServiceReference* object, it is recommended that the caller supply the *ServiceReference* argument whenever appropriate, because it provides important context information to the operator in the event of problems.

The following example demonstrates the use of a log method to write a message into the log.

```
logService.log(  
    myServiceReference,  
    LogService.LOG_INFO,  
    "myService is up and running"  
);
```

In the example, the myServiceReference parameter identifies the service associated with the log request. The specified level, LogService.LOG_INFO, indicates that this message is informational.

The following example code records error conditions as log messages.

```
try {  
    FileInputStream fis = new FileInputStream("myFile");  
    int b;  
    while ( (b = fis.read()) != -1 ) {  
        ...  
    }  
    fis.close();  
}  
catch ( IOException exception ) {  
    logService.log(  
        myServiceReference,  
        LogService.LOG_ERROR,  
        "Cannot access file",  
        exception );  
}
```

Notice that in addition to the error message, the exception itself is also logged. Providing this information can significantly simplify problem determination by the Operator.

101.3 Log Level and Error Severity

The log methods expect a log level indicating error severity, which can be used to filter log messages when they are retrieved. The severity levels are defined in the LogService interface.

Callers must supply the log levels that they deem appropriate when making log requests. The following table lists the log levels.

Table 2	Log Levels
Level	Descriptions
LOG_DEBUG	Used for problem determination and may be irrelevant to anyone but the bundle developer.
LOG_ERROR	Indicates the bundle or service may not be functional. Action should be taken to correct this situation.
LOG_INFO	May be the result of any change in the bundle or service and does not indicate a problem.
LOG_WARNING	Indicates a bundle or service is still functioning but may experience problems in the future because of the warning condition.

101.4 Log Reader Service

The Log Reader Service maintains a list of `LogEntry` objects called the *log*. The Log Reader Service is a service that bundle developers can use to retrieve information contained in this log, and receive notifications about `LogEntry` objects when they are created through the Log Service.

The size of the log is implementation-specific, and it determines how far into the past the log entries go. Additionally, some log entries may not be recorded in the log in order to save space. In particular, `LOG_DEBUG` log entries may not be recorded. Note that this rule is implementation-dependent. Some implementations may allow a configurable policy to ignore certain `LogEntry` object types.

The `LogReaderService` interface defines these methods for retrieving log entries.

- `getLog()` – This method retrieves past log entries as an enumeration with the most recent entry first.
- `addLogListener(LogListener)` – This method is used to subscribe to the Log Reader Service in order to receive log messages as they occur. Unlike the previously recorded log entries, all log messages must be sent to subscribers of the Log Reader Service as they are recorded. A subscriber to the Log Reader Service must implement the `LogListener` interface.

After a subscription to the Log Reader Service has been started, the subscriber's `LogListener.logged` method must be called with a `LogEntry` object for the message each time a message is logged.

The `LogListener` interface defines the following method:

- `logged(LogEntry)` – This method is called for each `LogEntry` object created. A Log Reader Service implementation must not filter entries to the `LogListener` interface as it is allowed to do for its log. A `LogListener` object should see all `LogEntry` objects that are created.

The delivery of `LogEntry` objects to the `LogListener` object should be done asynchronously.

101.5 Log Entry Interface

The `LogEntry` interface abstracts a log entry. It is a record of the information that was passed when an event was logged, and consists of a superset of information which can be passed through the `LogService` methods. The `LogEntry` interface defines these methods to retrieve information related to `LogEntry` objects:

- `getBundle()` – This method returns the `Bundle` object related to a `LogEntry` object.
- `getException()` – This method returns the exception related to a `LogEntry` object. In some implementations, the returned exception may not be the original exception. To avoid references to a bundle defined exception class, thus preventing an uninstalled bundle from being garbage collected, the Log Service may return an exception object of an

- implementation defined Throwable subclass. This object will attempt to return as much information as possible, such as the message and stack trace, from the original exception object .
- `getLevel()` – This method returns the severity level related to a LogEntry object.
 - `getMessage()` – This method returns the message related to a LogEntry object.
 - `getServiceReference()` –This method returns the ServiceReference object of the service related to a LogEntry object.
 - `getTime()` – This method returns the time that the log entry was created.

101.6 Mapping of Events

Implementations of a Log Service must log Framework-generated events and map the information to LogEntry objects in a consistent way. Framework events must be treated exactly the same as other logged events and distributed to all LogListener objects that are associated with the Log Reader Service. The following sections define the mapping for the three different event types: Bundle, Service, and Framework.

101.6.1 Bundle Events Mapping

A Bundle Event is mapped to a LogEntry object according to Table 3, “Mapping of Bundle Events to Log Entries,” on page 7.

Log Entry method	Information about Bundle Event
<code>getLevel()</code>	LOG_INFO
<code>getBundle()</code>	Identifies the bundle to which the event happened. In other words, it identifies the bundle that was installed, started, stopped, updated, or uninstalled. This identification is obtained by calling <code>getBundle()</code> on the BundleEvent object.
<code>getException()</code>	null
<code>getServiceReference()</code>	null
<code>getMessage()</code>	The message depends on the event type: <ul style="list-style-type: none">• INSTALLED – "BundleEvent INSTALLED"• STARTED – "BundleEvent STARTED"• STOPPED – "BundleEvent STOPPED"• UPDATED – "BundleEvent UPDATED"• UNINSTALLED – "BundleEvent UNINSTALLED"• RESOLVED – "BundleEvent RESOLVED"• UNRESOLVED – "BundleEvent UNRESOLVED"

101.6.2 Service Events Mapping

A Service Event is mapped to a LogEntry object according to Table 4, “Mapping of Service Events to Log Entries,” on page 8.

101.6.3 Framework Events Mapping

A Framework Event is mapped to a LogEntry object according to Table 5, “Mapping of Framework Event to Log Entries,” on page 8.

Table 4 Mapping of Service Events to Log Entries

Log Entry method	Information about Service Event
getLevel()	LOG_INFO, except for the ServiceEvent.MODIFIED event. This event can happen frequently and contains relatively little information. It must be logged with a level of LOG_DEBUG.
getBundle()	Identifies the bundle that registered the service associated with this event. It is obtained by calling getServiceReference().getBundle() on the ServiceEvent object.
getException()	null
getServiceReference()	Identifies a reference to the service associated with the event. It is obtained by calling getServiceReference() on the ServiceEvent object.
getMessage()	This message depends on the actual event type. The messages are mapped as follows: <ul style="list-style-type: none">• REGISTERED – "ServiceEvent REGISTERED"• MODIFIED – "ServiceEvent MODIFIED"• UNREGISTERING – "ServiceEvent UNREGISTERING"

Table 5 Mapping of Framework Event to Log Entries

Log Entry method	Information about Framework Event
getLevel()	LOG_INFO, except for the FrameworkEvent.ERROR event. This event represents an error and is logged with a level of LOG_ERROR.
getBundle()	Identifies the bundle associated with the event. This may be the system bundle. It is obtained by calling getBundle() on the FrameworkEvent object.
getException()	Identifies the exception associated with the error. This will be null for event types other than ERROR. It is obtained by calling getThrowable() on the FrameworkEvent object.
getServiceReference()	null
getMessage()	This message depends on the actual event type. The messages are mapped as follows: <ul style="list-style-type: none">• STARTED – "FrameworkEvent STARTED"• ERROR – "FrameworkEvent ERROR"• PACKAGES_REFRESHED – "FrameworkEvent PACKAGES REFRESHED"• STARTLEVEL_CHANGED – "FrameworkEvent STARTLEVEL CHANGED"• WARNING – "FrameworkEvent WARNING"• INFO – "FrameworkEvent INFO"

101.7 Security

The Log Service should only be implemented by trusted bundles. This bundle requires ServicePermission[LogService|LogReaderService, REGISTER]. Virtually all bundles should get ServicePermission[LogService, GET]. The ServicePermission[LogReaderService, GET] should only be assigned to trusted bundles.

101.8 Changes

The following clarifications were made.

- New Framework Event type strings are defined.
- New Bundle Event type strings are defined.

101.9 org.osgi.service.log

The OSGi Log Service Package. Specification Version 1.3.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.service.log; version=1.3

101.9.1 Summary

- *LogEntry* - Provides methods to access the information contained in an individual Log Service log entry. [p.9]
- *LogListener* - Subscribes to LogEntry objects from the LogReaderService. [p.10]
- *LogReaderService* - Provides methods to retrieve LogEntry objects from the log. [p.10]
- *LogService* - Provides methods for bundles to write messages to the log. [p.11]

101.9.2 public interface LogEntry

Provides methods to access the information contained in an individual Log Service log entry.

A LogEntry object may be acquired from the LogReaderService.getLog method or by registering a LogListener object.

See Also LogReaderService.getLog[p.11], LogListener[p.10]

101.9.2.1 public Bundle getBundle()

- Returns the bundle that created this LogEntry object.

Returns The bundle that created this LogEntry object; null if no bundle is associated with this LogEntry object.

101.9.2.2 public Throwable getException()

- Returns the exception object associated with this LogEntry object.

In some implementations, the returned exception may not be the original exception. To avoid references to a bundle defined exception class, thus preventing an uninstalled bundle from being garbage collected, the Log Service may return an exception object of an implementation defined Throwable subclass. The returned object will attempt to provide as much information as possible from the original exception object such as the message and stack trace.

Returns Throwable object of the exception associated with this LogEntry; null if no exception is associated with this LogEntry object.

101.9.2.3 public int getLevel()

- Returns the severity level of this LogEntry object.

This is one of the severity levels defined by the LogService interface.

Returns Severity level of this LogEntry object.

See Also LogService.LOG_ERROR[p.12], LogService.LOG_WARNING[p.12],
LogService.LOG_INFO[p.12], LogService.LOG_DEBUG[p.12]

101.9.2.4 public String getMessage()

- Returns the human readable message associated with this LogEntry object.

Returns String containing the message associated with this LogEntry object.

101.9.2.5 public ServiceReference getServiceReference()

- Returns the ServiceReference object for the service associated with this LogEntry object.

Returns ServiceReference object for the service associated with this LogEntry object; null if no ServiceReference object was provided.

101.9.2.6 public long getTime()

- Returns the value of currentTimeMillis() at the time this LogEntry object was created.

Returns The system time in milliseconds when this LogEntry object was created.

See Also System.currentTimeMillis()

**101.9.3 public interface LogListener
extends EventListener**

Subscribes to LogEntry objects from the LogReaderService.

A LogListener object may be registered with the Log Reader Service using the LogReaderService.addLogListener method. After the listener is registered, the logged method will be called for each LogEntry object created. The LogListener object may be unregistered by calling the LogReaderService.removeLogListener method.

See Also LogReaderService[p.10], LogEntry[p.9],
LogReaderService.addLogListener(LogListener)[p.11],
LogReaderService.removeLogListener(LogListener)[p.11]

101.9.3.1 public void logged(LogEntry entry)

entry A LogEntry object containing log information.

- Listener method called for each LogEntry object created.

As with all event listeners, this method should return to its caller as soon as possible.

See Also LogEntry[p.9]

101.9.4 public interface LogReaderService

Provides methods to retrieve LogEntry objects from the log.

There are two ways to retrieve LogEntry objects:

- The primary way to retrieve LogEntry objects is to register a LogListener object whose LogListener.logged method will be called for each entry added to the log.
- To retrieve past LogEntry objects, the getLog method can be called which will return an Enumeration of all LogEntry objects in the log.

See Also LogEntry[p.9], LogListener[p.10], LogListener.logged(LogEntry)[p.10]

101.9.4.1 **public void addLogListener(LogListener listener)**

listener A LogListener object to register; the LogListener object is used to receive LogEntry objects.

- Subscribes to LogEntry objects.

This method registers a LogListener object with the Log Reader Service. The LogListener.logged(LogEntry) method will be called for each LogEntry object placed into the log.

When a bundle which registers a LogListener object is stopped or otherwise releases the Log Reader Service, the Log Reader Service must remove all of the bundle's listeners.

If this Log Reader Service's list of listeners already contains a listener *l* such that (*l*==listener), this method does nothing.

See Also LogListener[p.10], LogEntry[p.9], LogListener.logged(LogEntry)[p.10]

101.9.4.2 **public Enumeration getLog()**

- Returns an Enumeration of all LogEntry objects in the log.

Each element of the enumeration is a LogEntry object, ordered with the most recent entry first. Whether the enumeration is of all LogEntry objects since the Log Service was started or some recent past is implementation-specific. Also implementation-specific is whether informational and debug LogEntry objects are included in the enumeration.

Returns An Enumeration of all LogEntry objects in the log.

101.9.4.3 **public void removeLogListener(LogListener listener)**

listener A LogListener object to unregister.

- Unsubscribes to LogEntry objects.

This method unregisters a LogListener object from the Log Reader Service.

If listener is not contained in this Log Reader Service's list of listeners, this method does nothing.

See Also LogListener[p.10]

101.9.5 **public interface LogService**

Provides methods for bundles to write messages to the log.

LogService methods are provided to log messages; optionally with a Service-Reference object or an exception.

Bundles must log messages in the OSGi environment with a severity level according to the following hierarchy:

- 1 LOG_ERROR[p.12]

2 LOG_WARNING[p.12]

3 LOG_INFO[p.12]

4 LOG_DEBUG[p.12]

101.9.5.1 **public static final int LOG_DEBUG = 4**

A debugging message (Value 4).

This log entry is used for problem determination and may be irrelevant to anyone but the bundle developer.

101.9.5.2 **public static final int LOG_ERROR = 1**

An error message (Value 1).

This log entry indicates the bundle or service may not be functional.

101.9.5.3 **public static final int LOG_INFO = 3**

An informational message (Value 3).

This log entry may be the result of any change in the bundle or service and does not indicate a problem.

101.9.5.4 **public static final int LOG_WARNING = 2**

A warning message (Value 2).

This log entry indicates a bundle or service is still functioning but may experience problems in the future because of the warning condition.

101.9.5.5 **public void log(int level, String message)**

level The severity of the message. This should be one of the defined log levels but may be any integer that is interpreted in a user defined way.

message Human readable string describing the condition or null.

- Logs a message.

The ServiceReference field and the Throwable field of the LogEntry object will be set to null.

See Also LOG_ERROR[p.12], LOG_WARNING[p.12], LOG_INFO[p.12], LOG_DEBUG[p.12]

101.9.5.6 **public void log(int level, String message, Throwable exception)**

level The severity of the message. This should be one of the defined log levels but may be any integer that is interpreted in a user defined way.

message The human readable string describing the condition or null.

exception The exception that reflects the condition or null.

- Logs a message with an exception.

The ServiceReference field of the LogEntry object will be set to null.

See Also LOG_ERROR[p.12], LOG_WARNING[p.12], LOG_INFO[p.12], LOG_DEBUG[p.12]

101.9.5.7 **public void log(ServiceReference sr, int level, String message)**

sr The ServiceReference object of the service that this message is associated with or null.

level The severity of the message. This should be one of the defined log levels but may be any integer that is interpreted in a user defined way.

message Human readable string describing the condition or null.

- Logs a message associated with a specific ServiceReference object.

The Throwable field of the LogEntry will be set to null.

See Also LOG_ERROR[p.12], LOG_WARNING[p.12], LOG_INFO[p.12], LOG_DEBUG[p.12]

101.9.5.8 public void log(ServiceReference sr, int level, String message, Throwable exception)

sr The ServiceReference object of the service that this message is associated with.

level The severity of the message. This should be one of the defined log levels but may be any integer that is interpreted in a user defined way.

message Human readable string describing the condition or null.

exception The exception that reflects the condition or null.

- Logs a message with an exception associated and a ServiceReference object.

See Also LOG_ERROR[p.12], LOG_WARNING[p.12], LOG_INFO[p.12], LOG_DEBUG[p.12]

102 Http Service Specification

Version 1.2

102.1 Introduction

An OSGi Service Platform normally provides users with access to services on the Internet and other networks. This access allows users to remotely retrieve information from, and send control to, services in an OSGi Service Platform using a standard web browser.

Bundle developers typically need to develop communication and user interface solutions for standard technologies such as HTTP, HTML, XML, and servlets.

The Http Service supports two standard techniques for this purpose:

- *Registering servlets* – A servlet is a Java object which implements the Java Servlet API. Registering a servlet in the Framework gives it control over some part of the Http Service URI name-space.
- *Registering resources* – Registering a resource allows HTML files, image files, and other static resources to be made visible in the Http Service URI name-space by the requesting bundle.

Implementations of the Http Service can be based on:

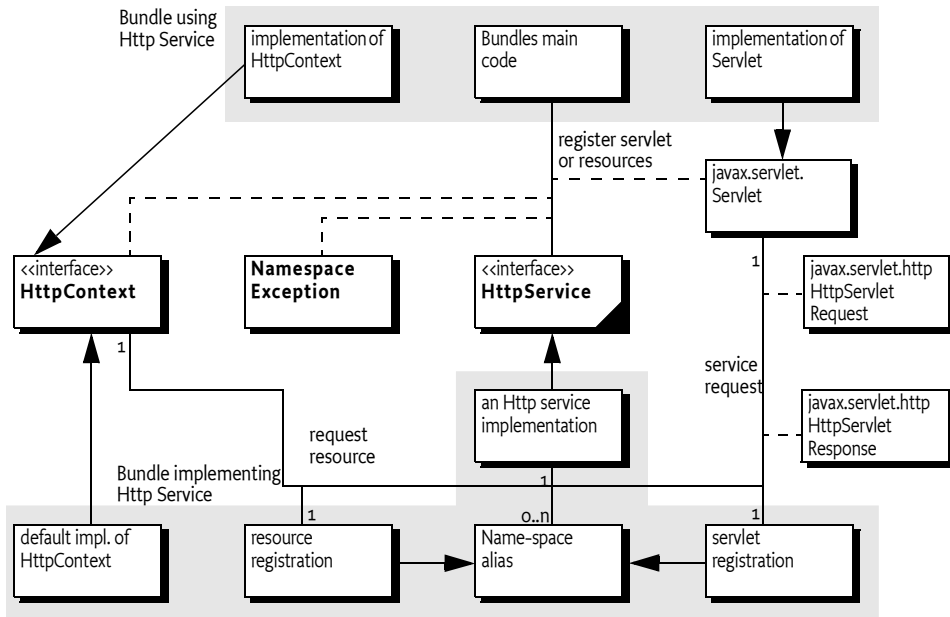
- [5] *HTTP 1.0 Specification RFC-1945*
- [6] *HTTP 1.1 Specification RFC-2616*

Alternatively, implementations of this service can support other protocols if these protocols can conform to the semantics of the `javax.servlet` API. This additional support is necessary because the Http Service is closely related to [7] *Java Servlet Technology*. Http Service implementations must support at least version 2.1 of the Java Servlet API.

102.1.1 Entities

This specification defines the following interfaces which a bundle developer can implement collectively as an Http Service or use individually:

- [HttpContext](#) – Allows bundles to provide information for a servlet or resource registration.
- [HttpService](#) – Allows other bundles in the Framework to dynamically register and unregister resources and servlets into the Http Service URI name-space.
- [NamespaceException](#) – Is thrown to indicate an error with the caller's request to register a servlet or resource into the Http Service URI name-space.

Figure 2 *Http Service Overview Diagram*

102.2 Registering Servlets

`javax.servlet.Servlet` objects can be registered with the Http Service by using the `HttpService` interface. For this purpose, the `HttpService` interface defines the method `registerServlet(String, javax.servlet.Servlet, Dictionary, HttpContext)`.

For example, if the Http Service implementation is listening to port 80 on the machine `www.acme.com` and the Servlet object is registered with the name `"/servlet"`, then the Servlet object's service method is called when the following URL is used from a web browser:

`http: //www. acme. com/ servlet?name=bugs`

All Servlet objects and resource registrations share the same name-space. If an attempt is made to register a resource or Servlet object under the same name as a currently registered resource or Servlet object, a `NamespaceException` is thrown. See *Mapping HTTP Requests to Servlet and Resource Registrations* on page 20 for more information about the handling of the Http Service name-space.

Each Servlet registration must be accompanied with an `HttpContext` object. This object provides the handling of resources, media typing, and a method to handle authentication of remote requests. See *Authentication* on page 23.

For convenience, a default `HttpContext` object is provided by the Http Service and can be obtained with `createDefaultHttpContext()`. Passing a null parameter to the registration method achieves the same effect.

Servlet objects require a ServletContext object. This object provides a number of functions to access the Http Service Java Servlet environment. It is created by the implementation of the Http Service for each unique HttpContext object with which a Servlet object is registered. Thus, Servlet objects registered with the same HttpContext object must also share the same ServletContext object.

Servlet objects are initialized by the Http Service when they are registered and bound to that specific Http Service. The initialization is done by calling the Servlet object's Servlet.init(ServletConfig) method. The ServletConfig parameter provides access to the initialization parameters specified when the Servlet object was registered.

Therefore, the same Servlet instance must not be reused for registration with another Http Service, nor can it be registered under multiple names. Unique instances are required for each registration.

The following example code demonstrates the use of the registerServlet method:

```
Hashtable initparams = new Hashtable();
initparams.put( "name", "value" );

Servlet myServlet = new HttpServlet() {
    String      name = "<not set>";

    public void init( ServletConfig config ) {
        this.name = (String)
            config.getInitParameter( "name" );
    }

    public void doGet(
        HttpServletRequest req,
        HttpServletResponse rsp
    ) throws IOException {
        rsp.setContentType( "text/plain" );
        req.getWriter().println( this.name );
    }
};

getHttpService().registerServlet(
    "/servletAlias",
    myServlet,
    initparams,
    null // use default context
);
// myServlet has been registered
// and its init method has been called. Remote
// requests are now handled and forwarded to
// the servlet.
...
getHttpService().unregister("/servletAlias");
// myServlet has been unregistered and its
// destroy method has been called
```

This example registers the servlet, `myServlet`, at alias: `/servletAlias`. Future requests for `http://www.acme.com/servletAlias` maps to the servlet, `myServlet`, whose service method is called to process the request. (The service method is called in the `HttpServlet` base class and dispatched to a `doGet`, `doPut`, `doPost`, `doOptions`, `doTrace`, or `doDelete` call depending on the HTTP request method used.)

102.3 Registering Resources

A resource is a file containing images, static HTML pages, sounds, movies, applets, etc. Resources do not require any handling from the bundle. They are transferred directly from their source—usually the JAR file that contains the code for the bundle—to the requestor using HTTP.

Resources could be handled by Servlet objects as explained in *Registering Servlets* on page 16. Transferring a resource over HTTP, however, would require very similar Servlet objects for each bundle. To prevent this redundancy, resources can be registered directly with the Http Service via the [HttpService](#) interface. This `HttpService` interface defines the [registerResources\(String,String,HttpContext\)](#) method for registering a resource into the Http Service URI name-space.

The first parameter is the external alias under which the resource is registered with the Http Service. The second parameter is an internal prefix to map this resource to the bundle's name-space. When a request is received, the `HttpService` object must remove the external alias from the URI, replace it with the internal prefix, and call the `getResource(String)` method with this new name on the associated `HttpContext` object. The `HttpContext` object is further used to get the MIME type of the resource and to authenticate the request.

Resources are returned as a `java.net.URL` object. The Http Service must read from this URL object and transfer the content to the initiator of the HTTP request.

This return type was chosen because it matches the return type of the `java.lang.Class.getResource(String resource)` method. This method can retrieve resources directly from the same place as the one from which the class was loaded – often a package directory in the JAR file of the bundle. This method makes it very convenient to retrieve resources from the bundle that are contained in the package.

The following example code demonstrates the use of the `registerResources` method:

```
package com.acme;
...
HttpContext context = new HttpContext() {
    public boolean handleSecurity(
        HttpServletRequest request,
        HttpServletResponse response
    ) throws IOException {
        return true;
    }
};
```

```
    }

    public URL getResource(String name) {
        return getClass().getResource(name);
    }

    public String getMimeType(String name) {
        return null;
    }
};

getHttpService().registerResources (
    "/files",
    "www",
    context
);
...
getHttpService().unregister("/files");
```

This example registers the alias /files on the Http Service. Requests for resources below this name-space are transferred to the HttpContext object with an internal name of www/<name>. This example uses the `Class.getResource(String)` method. Because the internal name does not start with a "/", it must map to a resource in the "com/acme/www" directory of the JAR file. If the internal name did start with a "/", the package name would not have to be prefixed and the JAR file would be searched from the root. Consult the `java.lang.Class.getResource(String)` method for more information.

In the example, a request for `http://www.acme.com/files/myfile.html` must map to the name "com/acme/www/myfile.html" which is in the bundle's JAR file.

More sophisticated implementations of the `getResource(String)` method could filter the input name, restricting the resources that may be returned or map the input name onto the file system (if the security implications of this action are acceptable).

Alternatively, the resource registration could have used a default HttpContext object, as demonstrated in the following call to `registerResources`:

```
getHttpService().registerResources (
    "/files",
    "/com/acme/www",
    null
);
```

In this case, the Http Service implementation would call the [createDefaultHttpContext\(\)](#) method and use its return value as the HttpContext argument for the `registerResources` method. The default implementation must map the resource request to the bundle's resource, using

`Bundle.getResource(String)`. In the case of the previous example, however, the internal name must now specify the full path to the directory containing the resource files in the JAR file. No automatic prefixing of the package name is done.

The `getMime(String)` implementation of the default `HttpContext` object should return a reasonable mapping. Its `handleSecurity(HttpServlet Request, HttpServletResponse)` may implement an authentication mechanism that is implementation-dependent.

102.4 Mapping HTTP Requests to Servlet and Resource Registrations

When an HTTP request comes in from a client, the Http Service checks to see if the requested URI matches any registered aliases. A URI matches only if the path part of the URI is exactly the same string. Matching is case sensitive.

If it does match, a matching registration takes place, which is processed as follows:

1. If the registration corresponds to a servlet, the authorization is verified by calling the `handleSecurity` method of the associated `HttpContext` object. See *Authentication* on page 23. If the request is authorized, the servlet must be called by its service method to complete the HTTP request.
2. If the registration corresponds to a resource, the authorization is verified by calling the `handleSecurity` method of the associated `HttpContext` object. See *Authentication* on page 23. If the request is authorized, a target resource name is constructed from the requested URI by substituting the alias from the registration with the internal name from the registration if the alias is not `"/"`. If the alias is `"/"`, then the target resource name is constructed by prefixing the requested URI with the internal name. An internal name of `"/"` is considered to have the value of the empty string `""` during this process.
3. The target resource name must be passed to the `getResource` method of the associated `HttpContext` object.
4. If the returned URL object is not null, the Http Service must return the contents of the URL to the client completing the HTTP request. The translated target name, as opposed to the original requested URI, must also be used as the argument to `HttpContext.getMimeType`.
5. If the returned URL object is null, the Http Service continues as if there was no match.
6. If there is no match, the Http Service must attempt to match sub-strings of the requested URI to registered aliases. The sub-strings of the requested URI are selected by removing the last `"/"` and everything to the right of the last `"/"`.

The Http Service must repeat this process until either a match is found or the sub-string is an empty string. If the sub-string is empty and the alias "/" is registered, the request is considered to match the alias "/". Otherwise, the Http Service must return `HttpServletResponse.SC_NOT_FOUND(404)` to the client.

For example, an HTTP request comes in with a request URI of `/fudd/bugs/foo.txt`, and the only registered alias is `/fudd`. A search for `/fudd/bugs/foo.txt` will not match an alias. Therefore, the Http Service will search for the alias `/fudd/bugs` and the alias `/fudd`. The latter search will result in a match and the matched alias registration must be used.

Registrations for identical aliases are not allowed. If a bundle registers the alias `/fudd`, and another bundle tries to register the exactly the same alias, the second caller must receive a `NamespaceException` and its resource or servlet must *not* be registered. It could, however, register a similar alias – for example, `/fudd/bugs`, as long as no other registration for this alias already exists.

The following table shows some examples of the usage of the name-space.

Table 6 Examples of Name-space Mapping

Alias	Internal Name	URI	getResource Parameter
/	(empty string)	/fudd/bugs	/fudd/bugs
/	/	/fudd/bugs	/fudd/bugs
/	/tmp	/fudd/bugs	/tmp/bugs
/fudd	(empty string)	/fudd/bugs	/bugs
/fudd	/	/fudd/bugs	/bugs
/fudd	/tmp	/fudd/bugs	/tmp/bugs
/fudd	tmp	/fudd/bugs/x.gif	tmp/bugs/x.gif
/fudd/bugs/x.gif	tmp/y.gif	/fudd/bugs/x.gif	tmp/y.gif

102.5 The Default Http Context Object

The `HttpContext` object in the first example demonstrates simple implementations of the [HttpContext](#) interface methods. Alternatively, the example could have used a default `HttpContext` object, as demonstrated in the following call to `registerServlet`:

```
getHttpService().registerServlet(  
    "/servletAlias",  
    myServlet,  
    initparams,  
    null  
);
```

In this case, the Http Service implementation must call `createDefaultHttpContext` and use the return value as the `HttpContext` argument.

If the default `HttpContext` object, and thus the `ServletContext` object, is to be shared by multiple servlet registrations, the previous servlet registration example code needs to be changed to use the same default `HttpContext` object. This change is demonstrated in the next example:

```
HttpContext defaultContext =  
    getHttpService().createDefaultHttpContext();  
  
getHttpService().registerServlet(  
    "/servletAlias",  
    myServlet,  
    initparams,  
    defaultContext  
);  
  
// defaultContext can be reused  
// for further servlet registrations
```

102.6 Multipurpose Internet Mail Extension (MIME) Types

MIME defines an extensive set of headers and procedures to encode binary messages in US-ASCII mails. For an overview of all the related RFCs, consult [8] *MIME Multipurpose Internet Mail Extension*.

An important aspect of this extension is the type (file format) mechanism of the binary messages. The type is defined by a string containing a general category (text, application, image, audio and video, multipart, and message) followed by a "/" and a specific media type, as in the example, "text/html" for HTML formatted text files. A MIME type string can be followed by additional specifiers by separating key=value pairs with a ':'. These specifiers can be used, for example, to define character sets as follows:

```
text/plain ; charset=iso-8859-1
```

The Internet Assigned Number Authority (IANA) maintains a set of defined MIME media types. This list can be found at [9] *Assigned MIME Media Types*. MIME media types are extendable, and when any part of the type starts with the prefix "x-", it is assumed to be vendor-specific and can be used for testing. New types can be registered as described in [10] *Registration Procedures for new MIME media types*.

HTTP bases its media typing on the MIME RFCs. The "Content-Type" header should contain a MIME media type so that the browser can recognize the type and format the content correctly.

The source of the data must define the MIME media type for each transfer. Most operating systems do not support types for files, but use conventions based on file names, such as the last part of the file name after the last ".". This extension is then mapped to a media type.

Implementations of the Http Service should have a reasonable default of mapping common extensions to media types based on file extensions.

Table 7 Sample Extension to MIME Media Mapping

Extension	MIME media type	Description
.jpg .jpeg	image/jpeg	JPEG Files
.gif	image/gif	GIF Files
.css	text/css	Cascading Style Sheet Files
.txt	text/plain	Text Files
.wml	text/vnd.wap.wml	Wireless Access Protocol (WAP) Mark Language
.htm .html	text/html	Hyper Text Markup Language
.wbmp	image/vnd.wap.wbmp	Bitmaps for WAP

Only the bundle developer, however, knows exactly which files have what media type. The `HttpContext` interface can therefore be used to map this knowledge to the media type. The `HttpContext` class has the following method for this: [getMimeType\(String\)](#).

The implementation of this method should inspect the file name and use its internal knowledge to map this name to a MIME media type.

Simple implementations can extract the extension and look up this extension in a table.

Returning null from this method allows the Http Service implementation to use its default mapping mechanism.

102.7 Authentication

The Http Service has separated the authentication and authorization of a request from the execution of the request. This separation allows bundles to use available `Servlet` sub-classes while still providing bundle specific authentication and authorization of the requests.

Prior to servicing each incoming request, the Http Service calls the [handleSecurity\(javax.servlet.http.HttpServletRequest,javax.servlet.http.HttpServletResponse\)](#) method on the `HttpContext` object that is associated with the request URI. This method controls whether the request is processed in the normal manner or an authentication error is returned.

If an implementation wants to authenticate the request, it can use the authentication mechanisms of HTTP. See [11] *RFC 2617: HTTP Authentication: Basic and Digest Access Authentication*. These mechanisms normally interpret the headers and decide if the user identity is available, and if it is, whether that user has authenticated itself correctly.

There are many different ways of authenticating users, and the `handleSecurity` method on the `HttpContext` object can use whatever method it requires. If the method returns `true`, the request must continue to be processed using the potentially modified `HttpServletRequest` and `HttpServletResponse` objects. If the method returns `false`, the request must *not* be processed.

A common standard for HTTP is the basic authentication scheme that is not secure when used with HTTP. Basic authentication passes the password in base 64 encoded strings that are trivial to decode into clear text. Secure transport protocols like HTTPS use SSL to hide this information. With these protocols basic authentication is secure.

Using basic authentication requires the following steps:

1. If no Authorization header is set in the request, the method should set the WWW-Authenticate header in the response. This header indicates the desired authentication mechanism and the realm. For example, WWW-Authenticate: Basic realm="ACME".
The header should be set with the response object that is given as a parameter to the handleSecurity method. The handleSecurity method should set the status to HttpServletResponse.SC_UNAUTHORIZED (401) and return false.
2. Secure connections can be verified with the ServletRequest.getScheme() method. This method returns, for example, "https" for an SSL connection; the handleSecurity method can use this and other information to decide if the connection's security level is acceptable. If not, the handleSecurity method should set the status to HttpServletResponse.SC_FORBIDDEN (403) and return false.
3. Next, the request must be authenticated. When basic authentication is used, the Authorization header is available in the request and should be parsed to find the user and password. See [11] *RFC 2617: HTTP Authentication: Basic and Digest Access Authentication* for more information.
If the user cannot be authenticated, the status of the response object should be set to HttpServletResponse.SC_UNAUTHORIZED (401) and return false.
4. The authentication mechanism that is actually used and the identity of the authenticated user can be of interest to the Servlet object. Therefore, the implementation of the handleSecurity method should set this information in the request object using the ServletRequest.setAttribute method. This specification has defined a number of OSGi-specific attribute names for this purpose:
 - **AUTHENTICATION_TYPE** - Specifies the scheme used in authentication. A Servlet may retrieve the value of this attribute by calling the HttpServletRequest.getAuthType method. This attribute name is org.osgi.service.http.authentication.type.
 - **REMOTE_USER** - Specifies the name of the authenticated user. A Servlet may retrieve the value of this attribute by calling the HttpServletRequest.getRemoteUser method. This attribute name is org.osgi.service.http.authentication.remote.user.
 - **AUTHORIZATION** - If a User Admin service is available in the environment, then the handleSecurity method should set this attribute with the Authorization object obtained from the User Admin service. Such an object encapsulates the authentication of its remote user. A Servlet may retrieve the value of this attribute by calling ServletRequest.getAttribute(HttpContext.AUTHORIZATION). This header name is org.osgi.service.useradmin.authorization.

5. Once the request is authenticated and any attributes are set, the `handleSecurity` method should return true. This return indicates to the Http Service that the request is authorized and processing may continue. If the request is for a Servlet, the Http Service must then call the service method on the Servlet object.

102.8 Security

This section only applies when executing in an OSGi environment which is enforcing Java permissions.

102.8.1 Accessing Resources in Bundles

The Http Service must be granted `AdminPermission[* ,RESOURCE]` so that bundles may use a default `HttpContext` object. This is necessary because the implementation of the default `HttpContext` object must call `Bundle.getResource` to access the resources of a bundle and this method requires the caller to have `AdminPermission[bundle,RESOURCE]`.

Any bundle may access resources in its own bundle by calling `Class.getResource`. This operation is privileged. The resulting URL object may then be passed to the Http Service as the result of a `HttpContext.getResource` call. No further permission checks are performed when accessing bundle resource URL objects, so the Http Service does not need to be granted any additional permissions.

102.8.2 Accessing Other Types of Resources

In order to access resources that were not registered using the default `HttpContext` object, the Http Service must be granted sufficient privileges to access these resources. For example, if the `getResource` method of the registered `HttpContext` object returns a file URL, the Http Service requires the corresponding `FilePermission` to read the file. Similarly, if the `getResource` method of the registered `HttpContext` object returns an HTTP URL, the Http Service requires the corresponding `SocketPermission` to connect to the resource.

Therefore, in most cases, the Http Service should be a privileged service that is granted sufficient permission to serve any bundle's resources, no matter where these resources are located. Therefore, the Http Service must capture the `AccessControlContext` object of the bundle registering resources or a servlet, and then use the captured `AccessControlContext` object when accessing resources returned by the registered `HttpContext` object. This situation prevents a bundle from registering resources that it does not have permission to access.

Therefore, the Http Service should follow a scheme like the following example. When a resource or servlet is registered, it should capture the context.

```
AccessControlContext acc =  
    AccessController.getContext();
```

When a URL returned by the `getResource` method of the associated `HttpContext` object is called, the `Http Service` must call the `getResource` method in a `doPrivileged` construct using the `AccessControlContext` object of the registering bundle:

```
AccessController.doPrivileged(  
    new PrivilegedExceptionAction() {  
        public Object run() throws Exception {  
            ...  
        }  
    }, acc);
```

The `Http Service` must only use the captured `AccessControlContext` when accessing resource URL objects. `Servlet` and `HttpContext` objects must use a `doPrivileged` construct in their implementations when performing privileged operations.

102.9 Configuration Properties

If the `Http Service` does not have its port values configured through some other means, the `Http Service` implementation should use the following properties to determine the port values upon which to listen.

The following OSGi environment properties are used to specify default HTTP ports:

- `org.osgi.service.http.port` – This property specifies the port used for servlets and resources accessible via HTTP. The default value for this property is 80.
- `org.osgi.service.http.port.secure` – This property specifies the port used for servlets and resources accessible via HTTPS. The default value for this property is 443.

102.10 Changes

- `NamespaceException` has been updated to support the Java 1.4 nested exception methods.
- `AdminPermission` references were updated to specify the `RESOURCE` action.

102.11 org.osgi.service.http

The OSGi `Http Service Package`. Specification Version 1.2.

Bundles wishing to use this package must list the package in the `Import-Package` header of the bundle's manifest. For example:

`Import-Package: org.osgi.service.http; version=1.2`

102.11.1 Summary

- `HttpContext` - This interface defines methods that the `Http Service` may call to get information about a registration. [p.27]

- `HttpService` - The `Http Service` allows other bundles in the OSGi environment to dynamically register resources and servlets into the URI namespace of `Http Service`. [p.29]
- `NamespaceException` - A `NamespaceException` is thrown to indicate an error with the caller's request to register a servlet or resources into the URI namespace of the `Http Service`. [p.31]

102.11.2 public interface `HttpContext`

This interface defines methods that the `Http Service` may call to get information about a registration.

Servlets and resources may be registered with an `HttpContext` object; if no `HttpContext` object is specified, a default `HttpContext` object is used. Servlets that are registered using the same `HttpContext` object will share the same `ServletContext` object.

This interface is implemented by users of the `HttpService`.

102.11.2.1 **public static final String AUTHENTICATION_TYPE = "org.osgi.service.http.authentication.type"**

`HttpServletRequest` attribute specifying the scheme used in authentication. The value of the attribute can be retrieved by `HttpServletRequest.getAuthType`. This attribute name is `org.osgi.service.http.authentication.type`.

Since 1.1

102.11.2.2 **public static final String AUTHORIZATION = "org.osgi.service.useradmin.authorization"**

`HttpServletRequest` attribute specifying the `Authorization` object obtained from the `org.osgi.service.useradmin.UserAdmin` service. The value of the attribute can be retrieved by `HttpServletRequest.getAttribute(HttpContext.AUTHORIZATION)`. This attribute name is `org.osgi.service.useradmin.authorization`.

Since 1.1

102.11.2.3 **public static final String REMOTE_USER = "org.osgi.service.http.authentication.remote.user"**

`HttpServletRequest` attribute specifying the name of the authenticated user. The value of the attribute can be retrieved by `HttpServletRequest.getRemoteUser`. This attribute name is `org.osgi.service.http.authentication.remote.user`.

Since 1.1

102.11.2.4 **public String getMimeType(String name)**

name determine the MIME type for this name.

- Maps a name to a MIME type. Called by the `Http Service` to determine the MIME type for the name. For servlet registrations, the `Http Service` will call this method to support the `ServletContext` method `getMimeType`. For resource registrations, the `Http Service` will call this method to determine the MIME type for the `Content-Type` header in the response.

Returns MIME type (e.g. text/html) of the name or null to indicate that the Http Service should determine the MIME type itself.

102.11.2.5 public URL getResource(String name)

name the name of the requested resource

- Maps a resource name to a URL.

Called by the Http Service to map a resource name to a URL. For servlet registrations, Http Service will call this method to support the ServletContext methods getResource and getResourceAsStream. For resource registrations, Http Service will call this method to locate the named resource. The context can control from where resources come. For example, the resource can be mapped to a file in the bundle's persistent storage area via bundleContext.getDataFile(name).toURL() or to a resource in the context's bundle via getClass().getResource(name)

Returns URL that Http Service can use to read the resource or null if the resource does not exist.

102.11.2.6 public boolean handleSecurity(HttpServletRequest request, HttpServletResponse response) throws IOException

request the HTTP request

response the HTTP response

- Handles security for the specified request.

The Http Service calls this method prior to servicing the specified request. This method controls whether the request is processed in the normal manner or an error is returned.

If the request requires authentication and the Authorization header in the request is missing or not acceptable, then this method should set the WWW-Authenticate header in the response object, set the status in the response object to Unauthorized(401) and return false. See also RFC 2617: *HTTP Authentication: Basic and Digest Access Authentication* (available at <http://www.ietf.org/rfc/rfc2617.txt>).

If the request requires a secure connection and the getScheme method in the request does not return 'https' or some other acceptable secure protocol, then this method should set the status in the response object to Forbidden(403) and return false.

When this method returns false, the Http Service will send the response back to the client, thereby completing the request. When this method returns true, the Http Service will proceed with servicing the request.

If the specified request has been authenticated, this method must set the AUTHENTICATION_TYPE[p.27] request attribute to the type of authentication used, and the REMOTE_USER[p.27] request attribute to the remote user (request attributes are set using the setAttribute method on the request). If this method does not perform any authentication, it must not set these attributes.

If the authenticated user is also authorized to access certain resources, this method must set the `AUTHORIZATION`[p.27] request attribute to the Authorization object obtained from the `org.osgi.service.useradmin.UserAdmin` service.

The servlet responsible for servicing the specified request determines the authentication type and remote user by calling the `getAuthType` and `getRemoteUser` methods, respectively, on the request.

Returns true if the request should be serviced, false if the request should not be serviced and Http Service will send the response back to the client.

Throws `IOException` – may be thrown by this method. If this occurs, the Http Service will terminate the request and close the socket.

102.11.3 public interface `HttpService`

The Http Service allows other bundles in the OSGi environment to dynamically register resources and servlets into the URI namespace of Http Service. A bundle may later unregister its resources or servlets.

See Also `HttpContext`[p.27]

102.11.3.1 public `HttpContext` `createDefaultHttpContext()`

- Creates a default `HttpContext` for registering servlets or resources with the `HttpService`, a new `HttpContext` object is created each time this method is called.

The behavior of the methods on the default `HttpContext` is defined as follows:

- `getMimeType`- Does not define any customized MIME types for the Content-Type header in the response, and always returns null.
- `handleSecurity`- Performs implementation-defined authentication on the request.
- `getResource`- Assumes the named resource is in the context bundle; this method calls the context bundle's `Bundle.getResource` method, and returns the appropriate URL to access the resource. On a Java runtime environment that supports permissions, the Http Service needs to be granted `org.osgi.framework.AdminPermission[*;RESOURCE]`.

Returns a default `HttpContext` object.

Since 1.1

102.11.3.2 public void `registerResources(String alias, String name, HttpContext context)` throws `NamespaceException`

alias name in the URI namespace at which the resources are registered

name the base name of the resources that will be registered

context the `HttpContext` object for the registered resources, or null if a default `HttpContext` is to be created and used.

- Registers resources into the URI namespace.

The alias is the name in the URI namespace of the Http Service at which the registration will be mapped. An alias must begin with slash ("/") and must not end with slash ("/"), with the exception that an alias of the form "/" is used to denote the root alias. The name parameter must also not end with slash ("/"). See the specification text for details on how HTTP requests are mapped to servlet and resource registrations.

For example, suppose the resource name /tmp is registered to the alias /files. A request for /files/foo.txt will map to the resource name /tmp/foo.txt.

```
httpservice.registerResources("/files", "/", context);
```

The Http Service will call the HttpContext argument to map resource names to URLs and MIME types and to handle security for requests. If the HttpContext argument is null, a default HttpContext is used (see createDefaultHttpContext[p.29]).

Throws `NamespaceException` – if the registration fails because the alias is already in use.

`IllegalArgumentException` – if any of the parameters are invalid

102.11.3.3 **public void registerServlet(String alias, Servlet servlet, Dictionary initparams, HttpContext context) throws ServletException, NamespaceException**

alias name in the URI namespace at which the servlet is registered

servlet the servlet object to register

initparams initialization arguments for the servlet or null if there are none. This argument is used by the servlet's ServletConfig object.

context the HttpContext object for the registered servlet, or null if a default HttpContext is to be created and used.

- Registers a servlet into the URI namespace.

The alias is the name in the URI namespace of the Http Service at which the registration will be mapped.

An alias must begin with slash ("/") and must not end with slash ("/"), with the exception that an alias of the form "/" is used to denote the root alias. See the specification text for details on how HTTP requests are mapped to servlet and resource registrations.

The Http Service will call the servlet's init method before returning.

```
httpService.registerServlet("/myservlet", servlet, initparams, context);
```

Servlets registered with the same HttpContext object will share the same ServletContext. The Http Service will call the context argument to support the ServletContext methods getResource, getResourceAsStream and getMimeType, and to handle security for requests. If the context argument is null, a default HttpContext object is used (see createDefaultHttpContext[p.29]).

Throws `NamespaceException` – if the registration fails because the alias is already in use.

`javax.servlet.ServletException` – if the servlet's `init` method throws an exception, or the given servlet object has already been registered at a different alias.

`IllegalArgumentException` – if any of the arguments are invalid

102.11.3.4 **public void unregister(String alias)**

alias name in the URI name-space of the registration to unregister

- Unregisters a previous registration done by `registerServlet` or `registerResources` methods.

After this call, the registered alias in the URI name-space will no longer be available. If the registration was for a servlet, the Http Service must call the `destroy` method of the servlet before returning.

If the bundle which performed the registration is stopped or otherwise “unget”s the Http Service without calling `unregister`[p.31] then Http Service must automatically unregister the registration. However, if the registration was for a servlet, the `destroy` method of the servlet will not be called in this case since the bundle may be stopped. `unregister`[p.31] must be explicitly called to cause the `destroy` method of the servlet to be called. This can be done in the `BundleActivator.stop` method of the bundle registering the servlet.

Throws `IllegalArgumentException` – if there is no registration for the alias or the calling bundle was not the bundle which registered the alias.

102.11.4 **public class NamespaceException extends Exception**

A `NamespaceException` is thrown to indicate an error with the caller's request to register a servlet or resources into the URI namespace of the Http Service. This exception indicates that the requested alias already is in use.

102.11.4.1 **public NamespaceException(String message)**

message the detail message

- Construct a `NamespaceException` object with a detail message.

102.11.4.2 **public NamespaceException(String message, Throwable cause)**

message The detail message.

cause The nested exception.

- Construct a `NamespaceException` object with a detail message and a nested exception.

102.11.4.3 **public Throwable getCause()**

- Returns the cause of this exception or null if no cause was specified when this exception was created.

Returns The cause of this exception or null if no cause was specified.

Since 1.2

102.11.4.4 public Throwable getException()

- Returns the nested exception.

This method predates the general purpose exception chaining mechanism. The `getCause()[p.31]` method is now the preferred means of obtaining this information.

Returns the nested exception or null if there is no nested exception.

102.11.4.5 public Throwable initCause(Throwable cause)

cause Cause of the exception.

- The cause of this exception can only be set when constructed.

Returns This object.

Throws `IllegalStateException` – This method will always throw an `IllegalStateException` since the cause of this exception can only be set when constructed.

Since 1.2

102.12 References

- [5] *HTTP 1.0 Specification RFC-1945*
<http://www.ietf.org/rfc/rfc1945.txt>, May 1996
- [6] *HTTP 1.1 Specification RFC-2616*
<http://www.ietf.org/rfc/rfc2616.txt>, June 1999
- [7] *Java Servlet Technology*
<http://java.sun.com/products/servlet/index.html>
- [8] *MIME Multipurpose Internet Mail Extension*
<http://www.nacs.uci.edu/indiv/ehood/MIME/MIME.html>
- [9] *Assigned MIME Media Types*
<http://www.iana.org/assignments/media-types>
- [10] *Registration Procedures for new MIME media types*
<http://www.ietf.org/rfc/rfc2048.txt>
- [11] *RFC 2617: HTTP Authentication: Basic and Digest Access Authentication*
<http://www.ietf.org/rfc/rfc2617.txt>

103 Device Access Specification

Version 1.1

103.1 Introduction

A Service Platform is a meeting point for services and devices from many different vendors: a meeting point where users add and cancel service subscriptions, newly installed services find their corresponding input and output devices, and device drivers connect to their hardware.

In an OSGi Service Platform, these activities will dynamically take place while the Framework is running. Technologies such as USB and IEEE 1394 explicitly support plugging and unplugging devices at any time, and wireless technologies are even more dynamic.

This flexibility makes it hard to configure all aspects of an OSGi Service Platform, particularly those relating to devices. When all of the possible services and device requirements are factored in, each OSGi Service Platform will be unique. Therefore, automated mechanisms are needed that can be extended and customized, in order to minimize the configuration needs of the OSGi environment.

The Device Access specification supports the coordination of automatic detection and attachment of existing devices on an OSGi Service Platform, facilitates hot-plugging and -unplugging of new devices, and downloads and installs device drivers on demand.

This specification, however, deliberately does not prescribe any particular device or network technology, and mentioned technologies are used as examples only. Nor does it specify a particular device discovery method. Rather, this specification focuses on the attachment of devices supplied by different vendors. It emphasizes the development of standardized device interfaces to be defined in device categories, although no such device categories are defined in this specification.

103.1.1 Essentials

- *Embedded Devices* – OSGi bundles will likely run in embedded devices. This environment implies limited possibility for user interaction, and low-end devices will probably have resource limitations.
- *Remote Administration* – OSGi environments must support administration by a remote service provider.
- *Vendor Neutrality* – OSGi-compliant driver bundles will be supplied by different vendors; each driver bundle must be well-defined, documented, and replaceable.

- *Continuous Operation* – OSGi environments will be running for extended periods without being restarted, possibly continuously, requiring stable operation and stable resource consumption.
- *Dynamic Updates* – As much as possible, driver bundles must be individually replaceable without affecting unrelated bundles. In particular, the process of updating a bundle should not require a restart of the whole OSGi Service Platform or disrupt operation of connected devices.

A number of requirements must be satisfied by Device Access implementations in order for them to be OSGi-compliant. Implementations must support the following capabilities:

- *Hot-Plugging* – Plugging and unplugging of devices at any time if the underlying hardware and drivers allow it.
- *Legacy Systems* – Device technologies which do not implement the automatic detection of plugged and unplugged devices.
- *Dynamic Device Driver Loading* – Loading new driver bundles on demand with no prior device-specific knowledge of the Device service.
- *Multiple Device Representations* – Devices to be accessed from multiple levels of abstraction.
- *Deep Trees* – Connections of devices in a tree of mixed network technologies of arbitrary depth.
- *Topology Independence* – Separation of the interfaces of a device from where and how it is attached.
- *Complex Devices* – Multifunction devices and devices that have multiple configurations.

103.1.2 Operation

This specification defines the behavior of a device manager (which is *not* a service as might be expected). This device manager detects registration of Device services and is responsible for associating these devices with an appropriate Driver service. These tasks are done with the help of Driver Locator services and the Driver Selector service that allow a device manager to find a Driver bundle and install it.

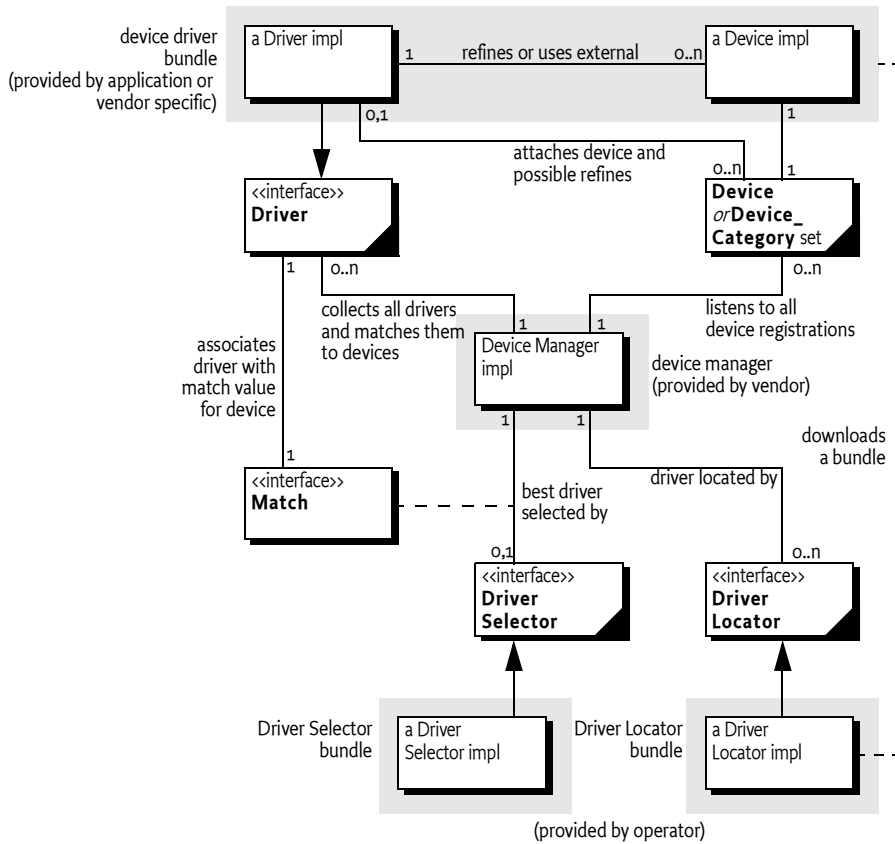
103.1.3 Entities

The main entities of the Device Access specification are:

- *Device Manager* – The bundle that controls the initiation of the attachment process behind the scenes.
- *Device Category* – Defines how a Driver service and a Device service can cooperate.
- *Driver* – Competes for attaching Device services of its recognized device category. See *Driver Services* on page 40.
- *Device* – A representation of a physical device or other entity that can be attached by a Driver service. See *Device Services* on page 35.
- *DriverLocator* – Assists in locating bundles that provide a Driver service. See *Driver Locator Service* on page 47.
- *DriverSelector* – Assists in selecting which Driver service is best suited to a Device service. See *The Driver Selector Service* on page 49.

Figure 3 show the classes and their relationships.

Figure 3 Device Access Class Overview



103.2 Device Services

A Device service represents some form of a device. It can represent a hardware device, but that is not a requirement. Device services differ widely: some represent individual physical devices and others represent complete networks. Several Device services can even simultaneously represent the same physical device at different levels of abstraction. For example:

- A USB network.
- A device attached on the USB network.
- The same device recognized as a USB to Ethernet bridge.
- A device discovered on the Ethernet using Salutation.
- The same device recognized as a simple printer.
- The same printer refined to a PostScript printer.

A device can also be represented in different ways. For example, a USB mouse can be considered as:

- A USB device which delivers information over the USB bus.
- A mouse device which delivers x and y coordinates and information about the state of its buttons.

Each representation has specific implications:

- That a particular device is a mouse is irrelevant to an application which provides management of USB devices.
- That a mouse is attached to a USB bus or a serial port would be inconsequential to applications that respond to mouse-like input.

Device services must belong to a defined *device category*, or else they can implement a generic service which models a particular device, independent of its underlying technology. Examples of this type of implementation could be Sensor or Actuator services.

A device category specifies the methods for communicating with a Device service, and enables interoperability between bundles that are based on the same underlying technology. Generic Device services will allow interoperability between bundles that are not coupled to specific device technologies.

For example, a device category is required for the USB, so that Driver bundles can be written that communicate to the devices that are attached to the USB. If a printer is attached, it should also be available as a generic Printer service defined in a Printer service specification, indistinguishable from a Printer service attached to a parallel port. Generic categories, such as a Printer service, should also be described in a Device Category.

It is expected that most Device service objects will actually represent a physical device in some form, but that is not a requirement of this specification. A Device service is represented as a normal service in the OSGi Framework and all coordination and activities are performed upon Framework services. This specification does not limit a bundle developer from using Framework mechanisms for services that are not related to physical devices.

103.2.1 Device Service Registration

A Device service is defined as a normal service registered with the Framework that either:

- Registers a service object under the interface `org.osgi.service.Device` with the Framework, or
- Sets the `DEVICE_CATEGORY` property in the registration. The value of `DEVICE_CATEGORY` is an array of String objects of all the device categories that the device belongs to. These strings are defined in the associated device category.

If this document mentions a Device service, it is meant to refer to services registered with the name `org.osgi.service.device.Device` or services registered with the `DEVICE_CATEGORY` property set.

When a Device service is registered, additional properties may be set that describe the device to the device manager and potentially to the end users. The following properties have their semantics defined in this specification:

- `DEVICE_CATEGORY` – A marker property indicating that this service must be regarded as a Device service by the device manager. Its value is of type `String[]`, and its meaning is defined in the associated device category specification.
- `DEVICE_DESCRIPTION` – Describes the device to an end user. Its value is of type `String`.

- **DEVICE_SERIAL** – A unique serial number for this device. If the device hardware contains a serial number, the driver bundle is encouraged to specify it as this property. Different Device services representing the same physical hardware at different abstraction levels should set the same **DEVICE_SERIAL**, thus simplifying identification. Its value is of type `String`.
- **service.pid** – Service Persistent ID (PID), defined in `org.osgi.framework.Constants`. Device services should set this property. It must be unique among all registered services. Even different abstraction levels of the same device must use different PIDs. The service PIDs must be reproducible, so that every time the same hardware is plugged in, the same PIDs are used.

103.2.2 Device Service Attachment

When a Device service is registered with the Framework, the device manager is responsible for finding a suitable Driver service and instructing it to attach to the newly registered Device service. The Device service itself is passive: it only registers a Device service with the Framework and then waits until it is called.

The actual communication with the underlying physical device is not defined in the Device interface because it differs significantly between different types of devices. The Driver service is responsible for attaching the device in a device type-specific manner. The rules and interfaces for this process must be defined in the appropriate device category.

If the device manager is unable to find a suitable Driver service, the Device service remains unattached. In that case, if the service object implements the Device interface, it must receive a call to the `noDriverFound()` method. The Device service can wait until a new driver is installed, or it can unregister and attempt to register again with different properties that describe a more generic device or try a different configuration.

103.2.2.1 Idle Device Service

The main purpose of the device manager is to try to attach drivers to idle devices. For this purpose, a Device service is considered *idle* if no bundle that itself has registered a Driver service is using the Device service.

103.2.2.2 Device Service Unregistration

When a Device service is unregistered, no immediate action is required by the device manager. The normal service of unregistering events, provided by the Framework, takes care of propagating the unregistration information to affected drivers. Drivers must take the appropriate action to release this Device service and perform any necessary cleanup, as described in their device category specification.

The device manager may, however, take a device unregistration as an indication that driver bundles may have become idle and are thus eligible for removal. It is therefore important for Device services to unregister their service object when the underlying entity becomes unavailable.

103.3 Device Category Specifications

A device category specifies the rules and interfaces needed for the communication between a Device service and a Driver service. Only Device services and Driver services of the same device category can communicate and cooperate.

The Device Access service specification is limited to the attachment of Device services by Driver services, and does *not* enumerate different device categories.

Other specifications must specify a number of device categories before this specification can be made operational. Without a set of defined device categories, no interoperability can be achieved.

Device categories are related to a specific device technology, such as USB, IEEE 1394, JINI, UPnP, Salutation, CEBus, Lonworks, and others. The purpose of a device category specification is to make all Device services of that category conform to an agreed interface, so that, for example, a USB Driver service of vendor A can control Device services from vendor B attached to a USB bus.

This specification is limited to defining the guidelines for device category definitions only. Device categories may be defined by the OSGi organization or by external specification bodies – for example, when these bodies are associated with a specific device technology.

103.3.1 Device Category Guidelines

A device category definition comprises the following elements:

- An interface that all devices belonging to this category must implement. This interface should lay out the rules of how to communicate with the underlying device. The specification body may define its own device interfaces (or classes) or leverage existing ones. For example, a serial port device category could use the `javax.comm.SerialPort` interface which is defined in [12] *Java Communications API*. When registering a device belonging to this category with the Framework, the interface or class name for this category must be included in the registration.
- A set of service registration properties, their data types, and semantics, each of which must be declared as either MANDATORY or OPTIONAL for this device category.
- A range of match values specific to this device category. Matching is explained later in *The Device Attachment Algorithm* on page 51.

103.3.2 Sample Device Category Specification

The following is a partial example of a fictitious device category:

```
public interface /* com.acme.widget.* / WidgetDevice {
    int MATCH_SERIAL           = 10;
    int MATCH_VERSION          = 8;
    int MATCH_MODEL            = 6;
    int MATCH_MAKE              = 4;
    int MATCH_CLASS            = 2;
```



```
void sendPacket( byte [] data );
byte [] receivePacket( long timeout );
}
```

Devices in this category must implement the interface `com.acme.widget.WidgetDevice` to receive attachments from Driver services in this category.

Device properties for this fictitious category are defined in table Table 8.

Table 8 *Example Device Category Properties, M=Mandatory, O=Optional*

Property name	M/O	Type	Value
DEVICE_CATEGORY	M	String[]	{"Widget"}
com.acme.class	M	String	A class description of this device. For example "audio", "video", "serial", etc. An actual device category specification should contain an exhaustive list and define a process to add new classes.
com.acme.model	M	String	A definition of the model. This is usually vendor specific. For example "Mouse".
com.acme.manufacturer	M	String	Manufacturer of this device, for example "ACME Widget Division".
com.acme.revision	O	String	Revision number. For example, "42".
com.acme.serial	O	String	A serial number. For example "SN6751293-12-2112/A".

103.3.3 **Match Example**

Driver services and Device services are connected via a matching process that is explained in *The Device Attachment Algorithm* on page 51. The Driver service plays a pivotal role in this matching process. It must inspect the Device service (from its `ServiceReference` object) that has just been registered and decide if it potentially could cooperate with this Device service.

It must be able to answer a value indicating the quality of the match. The scale of this match value must be defined in the device category so as to allow Driver services to match on a fair basis. The scale must start at least at 1 and go upwards.

Driver services for this sample device category must return one of the match codes defined in the `com.acme.widget.WidgetDevice` interface or `Device.MATCH_NONE` if the Device service is not recognized. The device category must define the exact rules for the match codes in the device category specification. In this example, a small range from 2 to 10 (`MATCH_NONE` is 0) is defined for `WidgetDevice` devices. They are named in the `WidgetDevice` interface for convenience and have the following semantics.

A Driver service should use the constants to return when it decides how closely the Device service matches its suitability. For example, if it matches the exact serial number, it should return `MATCH_SERIAL`.

Table 9 Sample Device Category Match Scale

Match name	Value	Description
MATCH_SERIAL	10	An exact match, including the serial number.
MATCH_VERSION	8	Matches the right class, make model, and version.
MATCH_MODEL	6	Matches the right class and make model.
MATCH_MAKE	4	Matches the make.
MATCH_CLASS	2	Only matches the class.

103.4 Driver Services

A Driver service is responsible for attaching to suitable Device services under control of the device manager. Before it can attach a Device service, however, it must compete with other Driver services for control.

If a Driver service wins the competition, it must attach the device in a device category-specific way. After that, it can perform its intended functionality. This functionality is not defined here nor in the device category; this specification only describes the behavior of the Device service, not how the Driver service uses it to implement its intended functionality. A Driver service may register one or more new Device services of another device category or a generic service which models a more refined form of the device.

Both refined Device services as well as generic services should be defined in a Device Category. See *Device Category Specifications* on page 38.

103.4.1 Driver Bundles

A Driver service is, like *all* services, implemented in a bundle, and is recognized by the device manager by registering one or more Driver service objects with the Framework.

Such bundles containing one or more Driver services are called *driver bundles*. The device manager must be aware of the fact that the cardinality of the relationship between bundles and Driver services is 1:1...*.

A driver bundle must register *at least* one Driver service in its BundleActivator.start implementation.

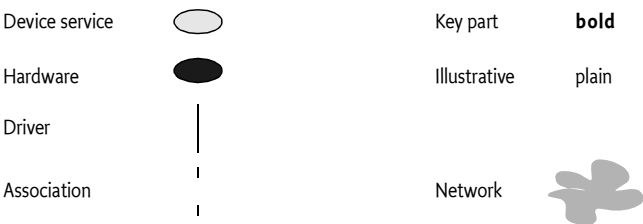
103.4.2 Driver Taxonomy

Device Drivers may belong to one of the following categories:

- Base Drivers (Discovery, Pure Discovery and Normal)
- Refining Drivers
- Network Drivers
- Composite Drivers
- Referring Drivers
- Bridging Drivers
- Multiplexing Drivers
- Pure Consuming Drivers

This list is not definitive, and a Driver service is not required to fit into one of these categories. The purpose of this taxonomy is to show the different topologies that have been considered for the Device Access service specification.

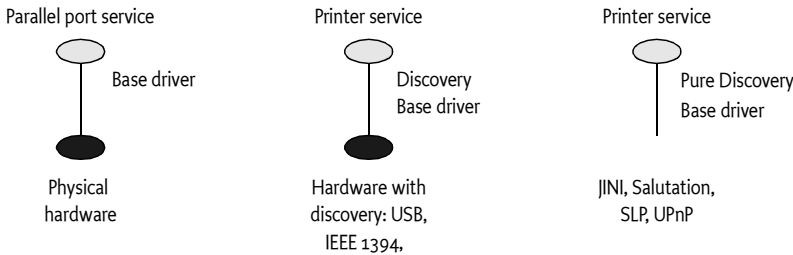
Figure 4 Legend for Device Driver Services Taxonomy



103.4.2.1 Base Drivers

The first category of device drivers are called *base drivers* because they provide the lowest-level representation of a physical device. The distinguishing factor is that they are not registered as Driver services because they do not have to compete for access to their underlying technology.

Figure 5 Base Driver Types



Base drivers discover physical devices using code not specified here (for example, through notifications from a device driver in native code) and then register corresponding Device services.

When the hardware supports a discovery mechanism and reports a physical device, a Device service is then registered. Drivers supporting a discovery mechanism are called *discovery base drivers*.

An example of a discovery base driver is a USB driver. Discovered USB devices are registered with the Framework as a generic USB Device service. The USB specification (see [13] *USB Specification*) defines a tightly integrated discovery method. Further, devices are individually addressed; no provision exists for broadcasting a message to all devices attached to the USB bus. Therefore, there is no reason to expose the USB network itself; instead, a discovery base driver can register the individual devices as they are discovered.

Not all technologies support a discovery mechanism. For example, most serial ports do not support detection, and it is often not even possible to detect whether a device is attached to a serial port.

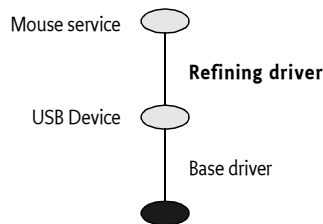
Although each driver bundle should perform discovery on its own, a driver for a non-discoverable serial port requires external help – either through a user interface or by allowing the Configuration Admin service to configure it.

It is possible for the driver bundle to combine automatic discovery of Plug and Play-compliant devices with manual configuration when non-compliant devices are plugged in.

103.4.2.2 Refining Drivers

The second category of device drivers are called *refining drivers*. Refining drivers provide a refined view of a physical device that is already represented by another Device service registered with the Framework. Refining drivers register a Driver service with the Framework. This Driver service is used by the device manager to attach the refining driver to a less refined Device service that is registered as a result of events within the Framework itself.

Figure 6 Refining Driver Diagram



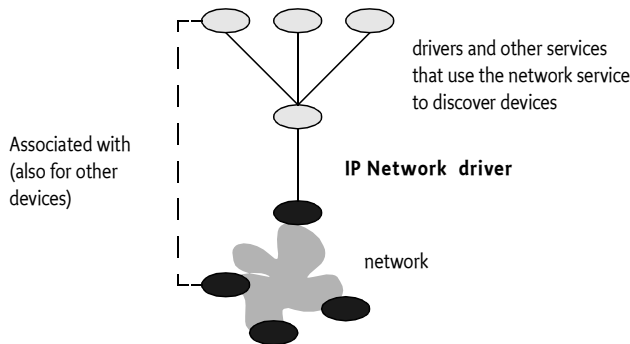
An example of a refining driver is a mouse driver, which is attached to the generic USB Device service representing a physical mouse. It then registers a new Device service which represents it as a Mouse service, defined elsewhere.

The majority of drivers fall into the refining driver type.

103.4.2.3 Network Drivers

An Internet Protocol (IP) capable network such as Ethernet supports individually addressable devices and allows broadcasts, but does not define an intrinsic discovery protocol. In this case, the entire network should be exposed as a single Device service.

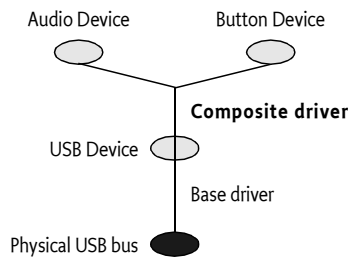
Figure 7 Network Driver diagram



103.4.2.4 Composite Drivers

Complex devices can often be broken down into several parts. Drivers that attach to a single service and then register multiple Device services are called *composite drivers*. For example, a USB speaker containing software-accessible buttons can be registered by its driver as two separate Device services: an Audio Device service and a Button Device service.

Figure 8 Composite Driver structure



This approach can greatly reduce the number of interfaces needed, as well as enhance reusability.

103.4.2.5 Referring Drivers

A referring driver is actually not a driver in the sense that it controls Device services. Instead, it acts as an intermediary to help locate the correct driver bundle. This process is explained in detail in *The Device Attachment Algorithm* on page 51.

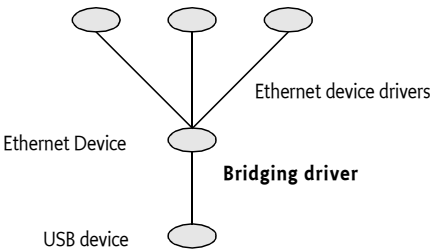
A referring driver implements the call to the attach method to inspect the Device service, and decides which Driver bundle would be able to attach to the device. This process can actually involve connecting to the physical device and communicating with it. The attach method then returns a String object that indicates the DRIVER_ID of another driver bundle. This process is called a referral.

For example, a vendor ACME can implement one driver bundle that specializes in recognizing all of the devices the vendor produces. The referring driver bundle does not contain code to control the device – it contains only sufficient logic to recognize the assortment of devices. This referring driver can be small, yet can still identify a large product line. This approach can drastically reduce the amount of downloading and matching needed to find the correct driver bundle.

103.4.2.6 Bridging Drivers

A bridging driver registers a Device service from one device category but attaches it to a Device service from another device category.

Figure 9 Bridging Driver Structure



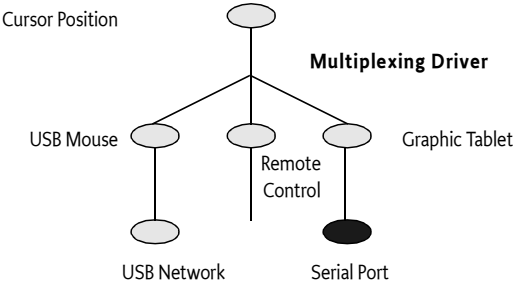
For example, USB to Ethernet bridges exist that allow connection to an Ethernet network through a USB device. In this case, the top level of the USB part of the Device service stack would be an Ethernet Device service. But the same Ethernet Device service can also be the bottom layer of an Ethernet layer of the Device service stack. A few layers up, a bridge could connect into yet another network.

The stacking depth of Device services has no limit, and the same drivers could in fact appear at different levels in the same Device service stack. The graph of drivers-to-Device services roughly mirrors the hardware connections.

103.4.2.7 Multiplexing Drivers

A *multiplexing driver* attaches a number of Device services and aggregates them in a new Device service.

Figure 10 Multiplexing Driver Structure



For example, assume that a system has a mouse on USB, a graphic tablet on a serial port, and a remote control facility. Each of these would be registered as a service with the Framework. A multiplexing driver can attach all three, and can merge the different positions in a central Cursor Position service.

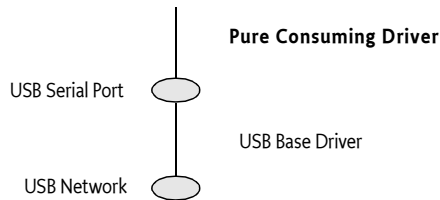
103.4.2.8

Pure Consuming Drivers

A *pure consuming driver* bundle will attach to devices without registering a refined version.

Figure 11

Pure Consuming Driver Structure



For example, one driver bundle could decide to handle all serial ports through `javax.comm` instead of registering them as services. When a USB serial port is plugged in, one or more Driver services are attached, resulting in a Device service stack with a Serial Port Device service. A pure consuming driver may then attach to the Serial Port Device service and register a new serial port with the `javax.comm.*` registry instead of the Framework service registry. This registration effectively transfers the device from the OSGi environment into another environment.

103.4.2.9

Other Driver Types

It should be noted that any bundle installed in the OSGi environment may get and use a Device service without having to register a Driver service.

The following functionality is offered to those bundles that do register a Driver service and conform to the this specification:

- The bundles can be installed and uninstalled on demand.
- Attachment to the Device service is only initiated after the winning the competition with other drivers.

103.4.3

Driver Service Registration

Drivers are recognized by registering a Driver service with the Framework. This event makes the device manager aware of the existence of the Driver service. A Driver service registration must have a `DRIVER_ID` property whose value is a String object, uniquely identifying the driver to the device manager. The device manager must use the `DRIVER_ID` to prevent the installation of duplicate copies of the same driver bundle.

Therefore, this `DRIVER_ID` must:

- Depend only on the specific behavior of the driver, and thus be independent of unrelated aspects like its location or mechanism of downloading.
- Start with the reversed form of the domain name of the company that implements it: for example, `com.acme.widget.1.1`.

- Differ from the DRIVER_ID of drivers with different behavior. Thus, it must *also* be different for each revision of the same driver bundle so they may be distinguished.

When a new Driver service is registered, the Device Attachment Algorithm must be applied to each idle Device service. This requirement gives the new Driver service a chance to compete with other Driver services for attaching to idle devices. The techniques outlined in *Optimizations* on page 54 can provide significant shortcuts for this situation.

As a result, the Driver service object can receive match and attach requests before the method which registered the service has returned.

This specification does not define any method for new Driver services to *steal* already attached devices. Once a Device service has been attached by a Driver service, it can only be released by the Driver service itself.

103.4.4 Driver Service Unregistration

When a Driver service is unregistered, it must release all Device services to which it is attached. Thus, *all* its attached Device services become idle. The device manager must gather all of these idle Device services and try to re-attach them. This condition gives other Driver services a chance to take over the refinement of devices after the unregistering driver. The techniques outlined in *Optimizations* on page 54 can provide significant shortcuts for this situation.

A Driver service that is installed by the device manager must remain registered as long as the driver bundle is active. Therefore, a Driver service should only be unregistered if the driver bundle is stopping, an occurrence which may precede its being uninstalled or updated. Driver services should thus not unregister in an attempt to minimize resource consumption. Such optimizations can easily introduce race conditions with the device manager.

103.4.5 Driver Service Methods

The Driver interface consists of the following methods:

- **match(ServiceReference)** – This method is called by the device manager to find out how well this Driver service matches the Device service as indicated by the ServiceReference argument. The value returned here is specific for a device category. If this Device service is of another device category, the value Device.MATCH_NONE must be returned. Higher values indicate a better match. For the exact matching algorithm, see *The Device Attachment Algorithm* on page 51.
Driver match values and referrals must be deterministic, in that repeated calls for the same Device service must return the same results so that results can be cached by the device manager.
- **attach(ServiceReference)** – If the device manager decides that a Driver service should be attached to a Device service, it must call this method on the Driver service object. Once this method is called, the Device service is regarded as attached to that Driver service, and no other Driver service must be called to attach to the Device service. The Device service must remain *owned* by the Driver service until the Driver bundle is stopped. No unattach method exists.

The attach method should return null when the Device service is correctly attached. A referring driver (see *Referring Drivers* on page 43) can return a String object that specifies the DRIVER_ID of a driver that can handle this Device service. In this case, the Device service is not attached and the device manager must attempt to install a Driver service with the same DRIVER_ID via a Driver Locator service. The attach method must be deterministic as described in the previous method.

103.4.6 Idle Driver Bundles

An idle Driver bundle is a bundle with a registered Driver service, and is not attached to any Device service. Idle Driver bundles are consuming resources in the OSGi Service Platform. The device manager should uninstall bundles that it has installed and which are idle.

103.5 Driver Locator Service

The device manager must automatically install Driver bundles, which are obtained from Driver Locator services, when new Device services are registered.

A Driver Locator service encapsulates the knowledge of how to fetch the Driver bundles needed for a specific Device service. This selection is made on the properties that are registered with a device: for example, DEVICE_CATEGORY and any other properties registered with the Device service registration.

The purpose of the Driver Locator service is to separate the mechanism from the policy. The decision to install a new bundle is made by the device manager (the mechanism), but a Driver Locator service decides which bundle to install and from where the bundle is downloaded (the policy).

Installing bundles has many consequences for the security of the system, and this process is also sensitive to network setup and other configuration details. Using Driver Locator services allows the Operator to choose a strategy that best fits its needs.

Driver services are identified by the DRIVER_ID property. Driver Locator services use this particular ID to identify the bundles that can be installed. Driver ID properties have uniqueness requirements as specified in *Device Service Registration* on page 36. This uniqueness allows the device manager to maintain a list of Driver services and prevent unnecessary installs.

An OSGi Service Platform can have several different Driver Locator services installed. The device manager must consult all of them and use the combined result set, after pruning duplicates based on the DRIVER_ID values.

103.5.1 The DriverLocator Interface

The [DriverLocator](#) interface allows suitable driver bundles to be located, downloaded, and installed on demand, even when completely unknown devices are detected.

It has the following methods:

- [findDrivers\(Dictionary\)](#) – This method returns an array of driver IDs that potentially match a service described by the properties in the Dictionary object. A driver ID is the String object that is registered by a Driver service under the DRIVER_ID property.
- [loadDriver\(String\)](#) – This method returns an InputStream object that can be used to download the bundle containing the Driver service as specified by the driver ID argument. If the Driver Locator service cannot download such a bundle, it should return null. Once this bundle is downloaded and installed in the Framework, it must register a Driver service with the DRIVER_ID property set to the value of the String argument.

103.5.2 A Driver Example

The following example shows a very minimal Driver service implementation. It consists of two classes. The first class is `SerialWidget`. This class tracks a single `WidgetDevice` from *Sample Device Category Specification* on page 38. It registers a `javax.comm.SerialPort` service, which is a general serial port specification that could also be implemented from other device categories like USB, a COM port, etc. It is created when the `SerialWidgetDriver` object is requested to attach a `WidgetDevice` by the device manager. It registers a new `javax.comm.SerialPort` service in its constructor.

The `org.osgi.util.tracker.ServiceTracker` is extended to handle the Framework events that are needed to simplify tracking this service. The `removedService` method of this class is overridden to unregister the `SerialPort` when the underlying `WidgetDevice` is unregistered.

```
package com.acme.widget;
import org.osgi.service.device.*;
import org.osgi.framework.*;
import org.osgi.util.tracker.*;

class SerialWidget extends ServiceTracker
    implements javax.comm.SerialPort,
               org.osgi.service.device.Constants {
    ServiceRegistration registration;

    SerialWidget( BundleContext c, ServiceReference r ) {
        super( c, r, null );
        open();
    }

    public Object addingService( ServiceReference ref ) {
        WidgetDevice dev = (WidgetDevice)
            context.getService( ref );
        registration = context.registerService(
            javax.comm.SerialPort.class.getName(),
            this,
            null );
        return dev;
    }

    public void removedService( ServiceReference ref,
```

```

        Object service ) {
            registration.unregister();
            context.ungetService(ref);
        }
        ... methods for javax.comm.SerialPort that are
        ... converted to underlying WidgetDevice
    }

```

A `SerialWidgetDriver` object is registered with the Framework in the Bundle Activator start method under the Driver interface. The device manager must call the match method for each idle Device service that is registered. If it is chosen by the device manager to control this Device service, a new `SerialWidget` is created that offers serial port functionality to other bundles.

```

public class SerialWidgetDriver implements Driver {
    BundleContext    context;

    String    spec =
        "&"
        + " (objectclass=com.acme.widget.WidgetDevice)"
        + " (DEVICE_CATEGORY=WidgetDevice)"
        + " (com.acme.class=Serial)"
        + ";";

    Filter    filter;

    SerialWidgetDriver( BundleContext context )
        throws Exception {
        this.context = context;
        filter = context.createFilter(spec);
    }
    public int match( ServiceReference d ) {
        if ( filter.match( d ) )
            return WidgetDevice.MATCH_CLASS;
        else
            return Device.MATCH_NONE;
    }
    public synchronized String attach(ServiceReference r){
        new SerialWidget( context, r );
    }
}

```

103.6 The Driver Selector Service

The purpose of the Driver Selector service is to customize the selection of the best Driver service from a set of suitable Driver bundles. The device manager has a default algorithm as described in *The Device Attachment Algorithm* on page 51. When this algorithm is not sufficient and requires customizing by the operator, a bundle providing a Driver Selector service can be installed in the Framework. This service must be used by the device manager as the final arbiter when selecting the best match for a Device service.

The Driver Selector service is a singleton; only one such service is recognized by the device manager. The Framework method `BundleContext.getServiceReference` must be used to obtain a Driver Selector service. In the erroneous case that multiple Driver Selector services are registered, the `service.ranking` property will thus define which service is actually used.

A device manager implementation must invoke the method `select(ServiceReference,Match[])`. This method receives a Service Reference to the Device service and an array of `Match` objects. Each `Match` object contains a link to the `ServiceReference` object of a Driver service and the result of the match value returned from a previous call to `Driver.match`. The Driver Selector service should inspect the array of `Match` objects and use some means to decide which Driver service is best suited. The index of the best match should be returned. If none of the `Match` objects describe a possible Driver service, the implementation must return `DriverSelector.SELECT_NONE (-1)`.

103.7 Device Manager

Device Access is controlled by the device manager in the background. The device manager is responsible for initiating all actions in response to the registration, modification, and unregistration of Device services and Driver services, using Driver Locator services and a Driver Selector service as helpers.

The device manager detects the registration of Device services and coordinates their attachment with a suitable Driver service. Potential Driver services do not have to be active in the Framework to be eligible. The device manager must use Driver Locator services to find bundles that might be suitable for the detected Device service and that are not currently installed. This selection is done via a `DRIVER_ID` property that is unique for each Driver service.

The device manager must install and start these bundles with the help of a Driver Locator service. This activity must result in the registration of one or more Driver services. All available Driver services, installed by the device manager and also others, then participate in a bidding process. The Driver service can inspect the Device service through its `ServiceReference` object to find out how well this Driver service matches the Device service.

If a Driver Selector service is available in the Framework service registry, it is used to decide which of the eligible Driver services is the best match.

If no Driver Selector service is available, the highest bidder must win, with tie breaks defined on the `service.ranking` and `service.id` properties. The selected Driver service is then asked to attach the Device service.

If no Driver service is suitable, the Device service remains idle. When new Driver bundles are installed, these idle Device services must be reattached.

The device manager must reattach a Device service if, at a later time, a Driver service is unregistered due to an uninstallation or update. At the same time, however, it should prevent superfluous and non-optimal reattachments. The device manager should also garbage-collect driver bundles it installed which are no longer used.

The device manager is a singleton. Only one device manager may exist, and it must have no public interface.

103.7.1 Device Manager Startup

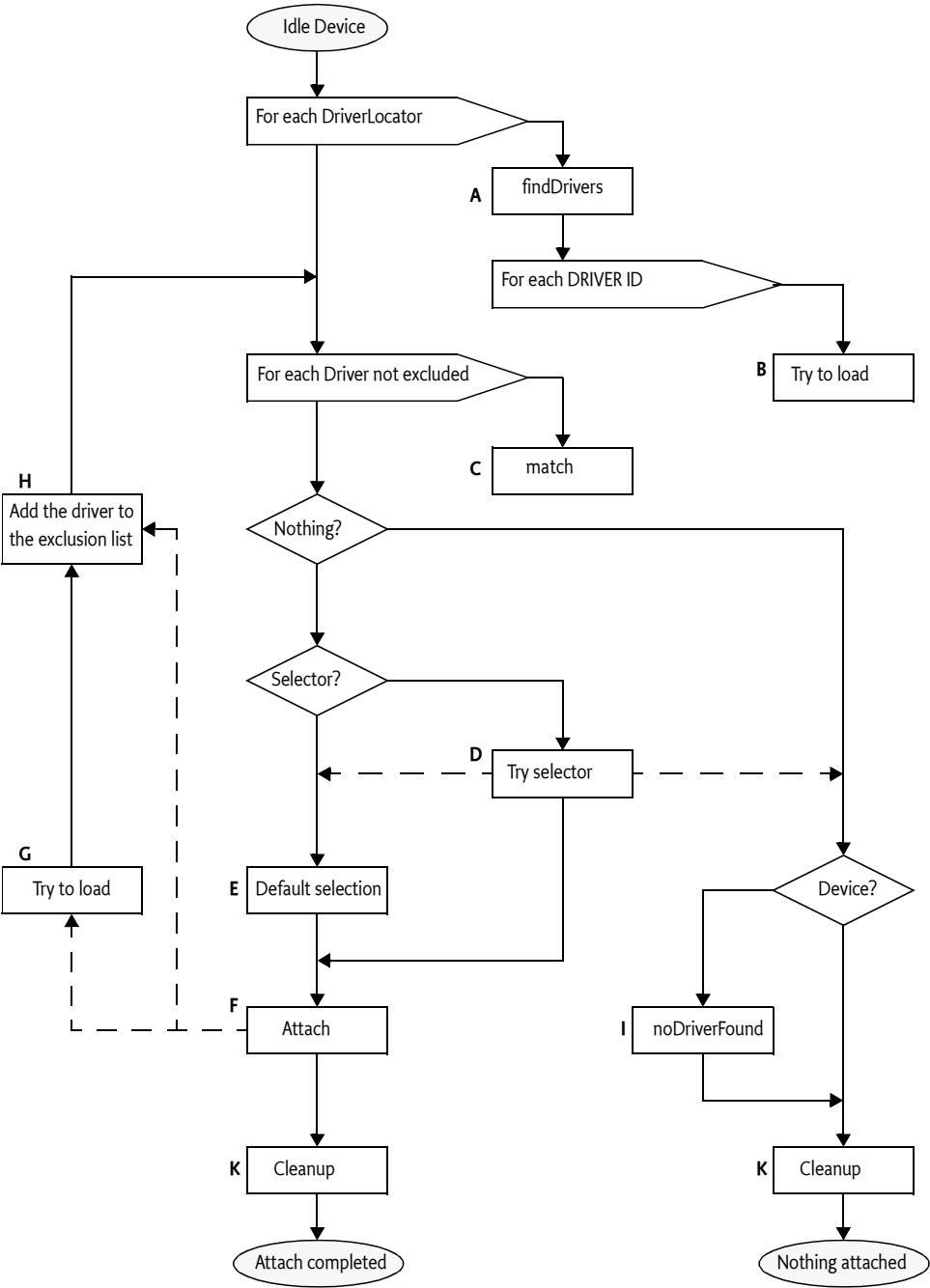
To prevent race conditions during Framework startup, the device manager must monitor the state of Device services and Driver services immediately when it is started. The device manager must not, however, begin attaching Device services until the Framework has been fully started, to prevent superfluous or non-optimal attachments.

The Framework has completed starting when the `FrameworkEvent.STARTED` event has been published. Publication of that event indicates that Framework has finished all its initialization and all bundles are started. If the device manager is started after the Framework has been initialized, it should detect the state of the Framework by examining the state of the system bundle.

103.7.2 The Device Attachment Algorithm

A key responsibility of the device manager is to attach refining drivers to idle devices. The following diagram illustrates the device attachment algorithm.

Figure 12 Device Attachment Algorithm



103.7.3
Table 10

Legend
Driver attachment algorithm

Step	Description
A	<p>DriverLocator.findDrivers is called for each registered Driver Locator service, passing the properties of the newly detected Device service. Each method call returns zero or more DRIVER_ID values (identifiers of particular driver bundles).</p> <p>If the findDrivers method throws an exception, it is ignored, and processing continues with the next Driver Locator service. See <i>Optimizations</i> on page 54 for further guidance on handling exceptions.</p>
B	<p>For each found DRIVER_ID that does not correspond to an already registered Driver service, the device manager calls DriverLocator.loadDriver to return an InputStream containing the driver bundle. Each call to loadDriver is directed to one of the Driver Locator services that mentioned the DRIVER_ID in step A. If the loadDriver method fails, the other Driver Locator objects are tried. If they all fail, the driver bundle is ignored.</p> <p>If this method succeeds, the device manager installs and starts the driver bundle. Driver bundles must register their Driver services synchronously during bundle activation.</p>
C	<p>For each Driver service, except those on the exclusion list, call its Driver.match method, passing the ServiceReference object to the Device service.</p> <p>Collect all successful matches – that is, those whose return values are greater than Device.MATCH_NONE – in a list of active matches. A match call that throws an exception is considered unsuccessful and is not added to the list.</p>
D	<p>If there is a Driver Selector service, the device manager calls the DriverSelector.select method, passing the array of active Match objects.</p> <p>If the Driver Selector service returns the index of one of the Match objects from the array, its associated Driver service is selected for attaching the Device service. If the Driver Selector service returns DriverSelector.SELECT_NONE, no Driver service must be considered for attaching the Device service.</p> <p>If the Driver Selector service throws an exception or returns an invalid result, the default selection algorithm is used.</p> <p>Only one Driver Selector service is used, even if there is more than one registered in the Framework. See <i>The Driver Selector Service</i> on page 49.</p>
E	<p>The winner is the one with the highest match value. Tie breakers are respectively:</p> <ul style="list-style-type: none">• Highest service.ranking property.• Lowest service.id property.

Table 10 *Driver attachment algorithm*

Step	Description
F	<p>The selected Driver service's attach method is called. If the attach method returns null, the Device service has been successfully attached. If the attach method returns a String object, it is interpreted as a referral to another Driver service and processing continues at G. See <i>Referring Drivers</i> on page 43.</p> <p>If an exception is thrown, the Driver service has failed, and the algorithm proceeds to try another Driver service after excluding this one from further consideration at Step H.</p>
G	<p>The device manager attempts to load the referred driver bundle in a manner similar to Step B, except that it is unknown which Driver Locator service to use. Therefore, the loadDriver method must be called on each Driver Locator service until one succeeds (or they all fail). If one succeeds, the device manager installs and starts the driver bundle. The driver bundle must register a Driver service during its activation which must be added to the list of Driver services in this algorithm.</p>
H	<p>The referring driver bundle is added to the exclusion list. Because each new referral adds an entry to the exclusion list, which in turn disqualifies another driver from further matching, the algorithm cannot loop indefinitely. This list is maintained for the duration of this algorithm. The next time a new Device service is processed, the exclusion list starts out empty.</p>
I	<p>If no Driver service attached the Device service, the Device service is checked to see whether it implements the Device interface. If so, the noDriverFound method is called. Note that this action may cause the Device service to unregister and possibly a new Device service (or services) to be registered in its place. Each new Device service registration must restart the algorithm from the beginning.</p>
K	<p>Whether an attachment was successful or not, the algorithm may have installed a number of driver bundles. The device manager should remove any idle driver bundles that it installed.</p>

103.7.4 Optimizations

- Optimizations are explicitly allowed and even recommended for an implementation of a device manager. Implementations may use the following assumptions:
- Driver match values and referrals must be deterministic, in that repeated calls for the same Device service must return the same results.
 - The device manager may cache match values and referrals. Therefore, optimizations in the device attachment algorithm based on this assumption are allowed.
 - The device manager may delay loading a driver bundle until it is needed. For example, a delay could occur when that DRIVER_ID's match values are cached.
 - The results of calls to DriverLocator and DriverSelector methods are not required to be deterministic, and must not be cached by the device manager.

- Thrown exceptions must not be cached. Exceptions are considered transient failures, and the device manager must always retry a method call even if it has thrown an exception on a previous invocation with the same arguments.

103.7.5 Driver Bundle Reclamation

The device manager may remove driver bundles it has installed at any time, provided that all the Driver services in that bundle are idle. This recommended practice prevents unused driver bundles from accumulating over time. Removing driver bundles too soon, however, may cause unnecessary installs and associated delays when driver bundles are needed again.

If a device manager implements driver bundle reclamation, the specified matching algorithm is not guaranteed to terminate unless the device manager takes reclamation into account.

For example, assume that a new Device service triggers the attachment algorithm. A driver bundle recommended by a Driver Locator service is loaded. It does not match, so the Device service remains idle. The device manager is eager to reclaim space, and unloads the driver bundle. The disappearance of the Driver service causes the device manager to reattach idle devices. Because it has not kept a record of its previous activities, it tries to reattach the same device, which closes the loop.

On systems where the device manager implements driver bundle reclamation, all refining drivers should be loaded through Driver Locator services. This recommendation is intended to prevent the device manager from erroneously uninstalling pre-installed driver bundles that cannot later be reinstalled when needed.

The device manager can be updated or restarted. It cannot, however, rely on previously stored information to determine which driver bundles were pre-installed and which were dynamically installed and thus are eligible for removal. The device manager may persistently store cachable information for optimization, but must be able to cold start without any persistent information and still be able to manage an existing connection state, satisfying all of the requirements in this specification.

103.7.6 Handling Driver Bundle Updates

It is not straightforward to determine whether a driver bundle is being updated when the UNREGISTER event for a Driver service is received. In order to facilitate this distinction, the device manager should wait for a period of time after the unregistration for one of the following events to occur:

- A BundleEvent.UNINSTALLED event for the driver bundle.
- A ServiceEvent.REGISTERED event for another Driver service registered by the driver bundle.

If the driver bundle is uninstalled, or if neither of the above events are received within the allotted time period, the driver is assumed to be inactive. The appropriate waiting period is implementation-dependent and will vary for different installations. As a general rule, this period should be long enough to allow a driver to be stopped, updated, and restarted under normal

conditions, and short enough not to cause unnecessary delays in reattaching devices. The actual time should be configurable.

103.7.7 **Simultaneous Device Service and Driver Service Registration**

The device attachment algorithm may discover new driver bundles that were installed outside its direct control, which requires executing the device attachment algorithm recursively. However, in this case, the appearance of the new driver bundles should be queued until completion of the current device attachment algorithm.

Only one device attachment algorithm may be in progress at any moment in time.

The following example sequence illustrates this process when a Driver service is registered:

- Collect the set of all idle devices.
- Apply the device attachment algorithm to each device in the set.
- If no Driver services were registered during the execution of the device attachment algorithm, processing terminates.
- Otherwise, restart this process.

103.8 **Security**

The device manager is the only privileged bundle in the Device Access specification and requires the `org.osgi.framework.AdminPermission` with the `LIFECYCLE` action to install and uninstall driver bundles.

The device manager itself should be free from any knowledge of policies and should not actively set bundle permissions. Rather, if permissions must be set, it is up to the Management Agent to listen to synchronous bundle events and set the appropriate permissions.

Driver Locator services can trigger the download of any bundle, because they deliver the content of a bundle to the privileged device manager and could potentially insert a Trojan horse into the environment. Therefore, Driver Locator bundles need the `ServicePermission[DriverLocator, REGISTER]` to register Driver Locator services, and the operator should exercise prudence in assigning this `ServicePermission`.

Bundles with Driver Selector services only require `ServicePermission[DriverSelector, REGISTER]` to register the `DriverSelector` service. The `DriverSelector` service can play a crucial role in the selection of a suitable Driver service, but it has no means to define a specific bundle itself.

103.9 **Changes**

The Device Access specification has not increased its version number because no API change has been necessary. The only change to this specification has been an update to reference the `LIFECYCLE` action of `AdminPermission`.

103.10 org.osgi.service.device

The OSGi Device Access Package. Specification Version 1.1.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.service.device; version=1.1

103.10.1 Summary

- Constants - This interface defines standard names for property keys associated with Device[p.58] and Driver[p.58] services. [p.57]
- Device - Interface for identifying device services. [p.58]
- Driver - A Driver service object must be registered by each Driver bundle wishing to attach to Device services provided by other drivers. [p.58]
- DriverLocator - A Driver Locator service can find and load device driver bundles given a property set. [p.59]
- DriverSelector - When the device manager detects a new Device service, it calls all registered Driver services to determine if anyone matches the Device service. [p.60]
- Match - Instances of Match are used in the DriverSelector.select[p.60] method to identify Driver services matching a Device service. [p.60]

103.10.2 public interface Constants

This interface defines standard names for property keys associated with Device[p.58] and Driver[p.58] services.

The values associated with these keys are of type java.lang.String, unless otherwise stated.

See Also Device[p.58], Driver[p.58]

Since 1.1

103.10.2.1 public static final String DEVICE_CATEGORY = "DEVICE_CATEGORY"

Property (named "DEVICE_CATEGORY") containing a human readable description of the device categories implemented by a device. This property is of type String[]

Services registered with this property will be treated as devices and discovered by the device manager

103.10.2.2 public static final String DEVICE_DESCRIPTION = "DEVICE_DESCRIPTION"

Property (named "DEVICE_DESCRIPTION") containing a human readable string describing the actual hardware device.

103.10.2.3 public static final String DEVICE_SERIAL = "DEVICE_SERIAL"

Property (named "DEVICE_SERIAL") specifying a device's serial number.

103.10.2.4 public static final String DRIVER_ID = "DRIVER_ID"

Property (named "DRIVER_ID") identifying a driver.

A DRIVER_ID should start with the reversed domain name of the company that implemented the driver (e.g., com.acme), and must meet the following requirements:

- It must be independent of the location from where it is obtained.
- It must be independent of the DriverLocator[p.59] service that downloaded it.
- It must be unique.
- It must be different for different revisions of the same driver.

This property is mandatory, i.e., every Driver service must be registered with it.

103.10.3 **public interface Device**

Interface for identifying device services.

A service must implement this interface or use the Constants.DEVICE_CATEGORY[p.57] registration property to indicate that it is a device. Any services implementing this interface or registered with the DEVICE_CATEGORY property will be discovered by the device manager.

Device services implementing this interface give the device manager the opportunity to indicate to the device that no drivers were found that could (further) refine it. In this case, the device manager calls the noDriverFound[p.58] method on the Device object.

Specialized device implementations will extend this interface by adding methods appropriate to their device category to it.

See Also Driver[p.58]

103.10.3.1 **public static final int MATCH_NONE = 0**

Return value from Driver.match[p.59] indicating that the driver cannot refine the device presented to it by the device manager. The value is zero.

103.10.3.2 **public void noDriverFound()**

- Indicates to this Device object that the device manager has failed to attach any drivers to it.

If this Device object can be configured differently, the driver that registered this Device object may unregister it and register a different Device service instead.

103.10.4 **public interface Driver**

A Driver service object must be registered by each Driver bundle wishing to attach to Device services provided by other drivers. For each newly discovered Device[p.58] object, the device manager enters a bidding phase. The Driver object whose match[p.59] method bids the highest for a particular Device object will be instructed by the device manager to attach to the Device object.

See Also Device[p.58], DriverLocator[p.59]

103.10.4.1 public String attach(ServiceReference reference) throws Exception

reference the ServiceReference object of the device to attach to

- Attaches this Driver service to the Device service represented by the given ServiceReference object.

A return value of null indicates that this Driver service has successfully attached to the given Device service. If this Driver service is unable to attach to the given Device service, but knows of a more suitable Driver service, it must return the DRIVER_ID of that Driver service. This allows for the implementation of referring drivers whose only purpose is to refer to other drivers capable of handling a given Device service.

After having attached to the Device service, this driver may register the underlying device as a new service exposing driver-specific functionality.

This method is called by the device manager.

Returns null if this Driver service has successfully attached to the given Device service, or the DRIVER_ID of a more suitable driver

Throws Exception – if the driver cannot attach to the given device and does not know of a more suitable driver

103.10.4.2 public int match(ServiceReference reference) throws Exception

reference the ServiceReference object of the device to match

- Checks whether this Driver service can be attached to the Device service. The Device service is represented by the given ServiceReference and returns a value indicating how well this driver can support the given Device service, or Device.MATCH_NONE[p.58] if it cannot support the given Device service at all.

The return value must be one of the possible match values defined in the device category definition for the given Device service, or Device.MATCH_NONE if the category of the Device service is not recognized.

In order to make its decision, this Driver service may examine the properties associated with the given Device service, or may get the referenced service object (representing the actual physical device) to talk to it, as long as it ungets the service and returns the physical device to a normal state before this method returns.

A Driver service must always return the same match code whenever it is presented with the same Device service.

The match function is called by the device manager during the matching process.

Returns value indicating how well this driver can support the given Device service, or Device.MATCH_NONE if it cannot support the Device service at all

Throws Exception – if this Driver service cannot examine the Device service

103.10.5 public interface DriverLocator

A Driver Locator service can find and load device driver bundles given a property set. Each driver is represented by a unique DRIVER_ID.

Driver Locator services provide the mechanism for dynamically downloading new device driver bundles into an OSGi environment. They are supplied by providers and encapsulate all provider-specific details related to the location and acquisition of driver bundles.

See Also [Driver](#)[p.58]

103.10.5.1 **public String[] findDrivers(Dictionary props)**

props the properties of the device for which a driver is sought

- Returns an array of DRIVER_ID strings of drivers capable of attaching to a device with the given properties.

The property keys in the specified Dictionary objects are case-insensitive.

Returns array of driver DRIVER_ID strings of drivers capable of attaching to a Device service with the given properties, or null if this Driver Locator service does not know of any such drivers

103.10.5.2 **public InputStream loadDriver(String id) throws IOException**

id the DRIVER_ID of the driver that needs to be installed.

- Get an InputStream from which the driver bundle providing a driver with the giving DRIVER_ID can be installed.

Returns An InputStream object from which the driver bundle can be installed or null if the driver with the given ID cannot be located

Throws IOException – the input stream for the bundle cannot be created

103.10.6 **public interface DriverSelector**

When the device manager detects a new Device service, it calls all registered Driver services to determine if anyone matches the Device service. If at least one Driver service matches, the device manager must choose one. If there is a Driver Selector service registered with the Framework, the device manager will ask it to make the selection. If there is no Driver Selector service, or if it returns an invalid result, or throws an Exception, the device manager uses the default selection strategy.

Since 1.1

103.10.6.1 **public static final int SELECT_NONE = -1**

Return value from DriverSelector.select, if no Driver service should be attached to the Device service. The value is -1.

103.10.6.2 **public int select(ServiceReference reference, Match[] matches)**

reference the ServiceReference object of the Device service.

matches the array of all non-zero matches.

- Select one of the matching Driver services. The device manager calls this method if there is at least one driver bidding for a device. Only Driver services that have responded with nonzero (not Device.MATCH_NONE[p.58]) match values will be included in the list.

Returns index into the array of Match objects, or SELECT_NONE if no Driver service should be attached

103.10.7 **public interface Match**

Instances of Match are used in the `DriverSelector.select[p.60]` method to identify Driver services matching a Device service.

See Also `DriverSelector[p.60]`

Since 1.1

103.10.7.1 **public ServiceReference getDriver()**

- Return the reference to a Driver service.

Returns ServiceReference object to a Driver service.

103.10.7.2 **public int getMatchValue()**

- Return the match value of this object.

Returns the match value returned by this Driver service.

103.11 **References**

- [12] *Java Communications API*
<http://java.sun.com/products/javacomm>
- [13] *USB Specification*
<http://www.usb.org>
- [14] *Universal Plug and Play*
<http://www.upnp.org>
- [15] *Jini, Service Discovery and Usage*
<http://www.jini.org/resources/>

104 Configuration Admin Service Specification

Version 1.2

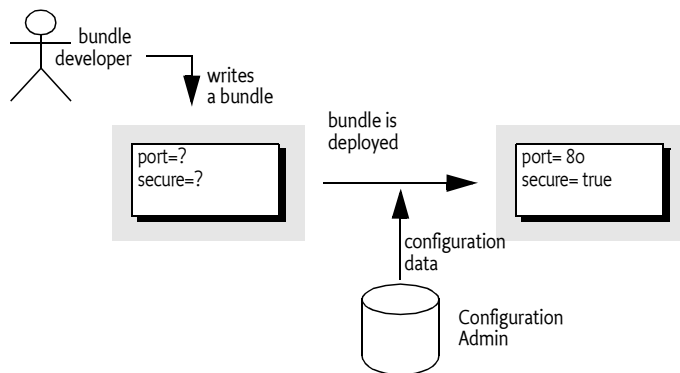
104.1 Introduction

The Configuration Admin service is an important aspect of the deployment of an OSGi Service Platform. It allows an Operator to set the configuration information of deployed bundles.

Configuration is the process of defining the configuration data of bundles and assuring that those bundles receive that data when they are active in the OSGi Service Platform.

Figure 13

Configuration Admin Service Overview



104.1.1

Essentials

The following requirements and patterns are associated with the Configuration Admin service specification:

- *Local Configuration* – The Configuration Admin service must support bundles that have their own user interface to change their configurations.
- *Reflection* – The Configuration Admin service must be able to deduce the names and types of the needed configuration data.
- *Legacy* – The Configuration Admin service must support configuration data of existing entities (such as devices).
- *Object Oriented* – The Configuration Admin service must support the creation and deletion of instances of configuration information so that a bundle can create the appropriate number of services under the control of the Configuration Admin service.

- *Embedded Devices* – The Configuration Admin service must be deployable on a wide range of platforms. This requirement means that the interface should not assume file storage on the platform. The choice to use file storage should be left to the implementation of the Configuration Admin service.
- *Remote versus Local Management* – The Configuration Admin service must allow for a remotely managed OSGi Service Platform, and must not assume that configuration information is stored locally. Nor should it assume that the Configuration Admin service is always done remotely. Both implementation approaches should be viable.
- *Availability* – The OSGi environment is a dynamic environment that must run continuously (24/7/365). Configuration updates must happen dynamically and should not require restarting of the system or bundles.
- *Immediate Response* – Changes in configuration should be reflected immediately.
- *Execution Environment* – The Configuration Admin service will not require more than an environment that fulfills the minimal execution requirements.
- *Communications* – The Configuration Admin service should not assume “always-on” connectivity, so the API is also applicable for mobile applications in cars, phones, or boats.
- *Extendability* – The Configuration Admin service should expose the process of configuration to other bundles. This exposure should at a minimum encompass initiating an update, removing certain configuration properties, adding properties, and modifying the value of properties potentially based on existing property or service values.
- *Complexity Trade-offs* – Bundles in need of configuration data should have a simple way of obtaining it. Most bundles have this need and the code to accept this data. Additionally, updates should be simple from the perspective of the receiver.
Trade-offs in simplicity should be made at the expense of the bundle implementing the Configuration Admin service and in favor of bundles that need configuration information. The reason for this choice is that normal bundles will outnumber Configuration Admin bundles.

104.1.2 Operation

This specification is based on the concept of a Configuration Admin service that manages the configuration of an OSGi Service Platform. It maintains a database of Configuration objects, locally or remote. This service monitors the service registry and provides configuration information to services that are registered with a `service.pid` property, the Persistent IDentity (PID), and implement one of the following interfaces:

- *Managed Service* – A service registered with this interface receives its *configuration dictionary* from the database or receives null when no such configuration exists or when an existing configuration has never been updated.
- *Managed Service Factory* – Services registered with this interface receive several configuration dictionaries when registered. The database contains zero or more configuration dictionaries for this service. Each configuration dictionary is given sequentially to the service.

The database can be manipulated either by the Management Agent or bundles that configure themselves.

Other parties can provide Configuration Plugin services. Such services participate in the configuration process. They can inspect the configuration dictionary and modify it before it reaches the target service.

104.1.3

Entities

- *Configuration information* – The information needed by a bundle before it can provide its intended functionality.
- *Configuration dictionary* – The configuration information when it is passed to the target service. It consists of a Dictionary object with a number of properties and identifiers.
- *Configuring Bundle* – A bundle that modifies the configuration information through the Configuration Admin service. This bundle is either a management bundle or the bundle for which the configuration information is intended.
- *Configuration Target* – The target (bundle or service) that will receive the configuration information. For services, there are two types of targets: ManagedServiceFactory or ManagedService objects.
- *Configuration Admin Service* – This service is responsible for supplying configuration target bundles with their configuration information. It maintains a database with configuration information, keyed on the service.pid of configuration target services. These services receive their configuration dictionary or dictionaries when they are registered with the Framework. Configurations can be modified or extended using Configuration Plugin services before they reach the target bundle.
- *Managed Service* – A Managed Service represents a client of the Configuration Admin service, and is thus a configuration target. Bundles should register a Managed Service to receive the configuration data from the Configuration Admin service. A Managed Service adds a unique service.pid service registration property as a primary key for the configuration information.
- *Managed Service Factory* – A Managed Service Factory can receive a number of configuration dictionaries from the Configuration Admin service, and is thus also a configuration target service. It should register with a service.pid and receives zero or more configuration dictionaries. Each dictionary has its own PID.
- *Configuration Object* – Implements the Configuration interface and contains the configuration dictionary for a Managed Service or one of the configuration dictionaries for a Managed Service Factory. These objects are manipulated by configuring bundles.
- *Configuration Plugin Services* – Configuration Plugin services are called before the configuration dictionary is given to the configuration targets. The plug-in can modify the configuration dictionary, which is passed to the Configuration Target.

The diagram illustrates the Configuration Admin architecture, showing the relationships between various bundles, interfaces, and objects.

Key Components and Bundles:

- bundle using ManagedService:** Contains `a Managed Service Impl`.
- bundle configuring:** Contains `a cnfg application (e.g. remote management)`.
- bundle using ManagedService Factory:** Contains `a configured instance of some type` and `a Managed Service Factory Impl`.
- Configuration Admin implementation bundle:** Contains `config. objects`, `Managed Service configuration impl`, and `Factory configuration impl`.
- plugin bundle:** Contains `Plugin Impl`.

Interfaces and Relationships:

- Managed Service:** An interface implemented by `a Managed Service Impl` (bundle using ManagedService) and `Factory configuration impl` (Configuration Admin implementation bundle). It has a `0..n` association with `config. objects` labeled "send configuration".
- Configuration:** An interface implemented by `config. objects` (Configuration Admin implementation bundle).
- Configuration Admin:** An interface implemented by `Configuration Adm. Impl.` (Configuration Admin implementation bundle). It has a `1` association with `config. objects` and a `1` association with `Managed Service configuration impl`.
- Man. Service Factory:** An interface implemented by `a Managed Service Factory Impl` (bundle using ManagedService Factory). It has a `0..n` association with `config. objects` labeled "send configuration information" and a `1` association with `Configuration Adm. Impl.` labeled "set configuration properties via".
- Configuration Plugin:** An interface implemented by `Plugin Impl` (plugin bundle). It has a `0..n` association with `config. objects` and a `1` association with `Configuration Adm. Impl.` labeled "Modify properties".

Other Relationships:

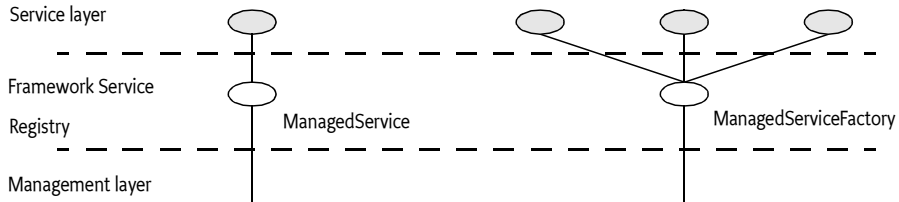
- `Config. Exception` is associated with `Managed Service` and `Configuration`.
- `config. objects` (Configuration Admin implementation bundle) has a `0..n` association with `Managed Service configuration impl` and a `0..n` association with `Factory configuration impl`.
- `config. objects` (Configuration Admin implementation bundle) has a `0..n` association with `Managed Service` labeled "send configuration".
- `config. objects` (Configuration Admin implementation bundle) has a `0..n` association with `Man. Service Factory` labeled "send configuration information".
- `config. objects` (Configuration Admin implementation bundle) has a `0..n` association with `Configuration Plugin`.

One of the more complicated aspects of this specification is the subtle distinction between the `ManagedService` and `ManagedServiceFactory` classes. Both receive configuration information from the Configuration Admin service and are treated similarly in most respects. Therefore, this specification refers to *configuration targets* when the distinction is irrelevant.

The difference between these types is related to the cardinality of the configuration dictionary. A Managed Service is used when an existing entity needs a configuration dictionary. Thus, a one-to-one relationship always exists between the configuration dictionary and the entity.

A Managed Service Factory is used when part of the configuration is to define *how many instances are required*. A management bundle can create, modify, and delete any number of instances for a Managed Service Factory through the Configuration Admin service. Each instance is configured by a single Configuration object. Therefore, a Managed Service Factory can have multiple associated Configuration objects.

Figure 15 *Differentiation of ManagedService and ManagedServiceFactory Classes*



To summarize:

- A *Managed Service* must receive a single configuration dictionary when it is registered or when its configuration is modified.
- A *Managed Service Factory* must receive from zero to n configuration dictionaries when it registers, depending on the current configuration. The Managed Service Factory is informed of configuration dictionary changes: modifications, creations, and deletions.

104.3 The Persistent Identity

A crucial concept in the Configuration Admin service specification is the Persistent IDentity (PID) as defined in the Framework's service layer. Its purpose is to act as a primary key for objects that need a configuration dictionary. The name of the service property for PID is defined in the Framework in `org.osgi.framework.Constants.SERVICE_PID`.

The Configuration Admin service requires the use of PIDs with Managed Service and Managed Service Factory registrations because it associates its configuration data with PIDs.

PIDs must be unique for each service. A bundle must not register multiple configuration target services with the same PID. If that should occur, the Configuration Admin service must:

- Send the appropriate configuration data to all services registered under that PID from that bundle only.
- Report an error in the log.
- Ignore duplicate PIDs from other bundles and report them to the log.

104.3.1 PID Syntax

PIDs are intended for use by other bundles, not by people, but sometimes the user is confronted with a PID. For example, when installing an alarm system, the user needs to identify the different components to a wiring application. This type of application exposes the PID to end users.

PIDs should follow the symbolic-name syntax, which uses a very restricted character set. The following sections, define some schemes for common cases. These schemes are not required, but bundle developers are urged to use them to achieve consistency.

104.3.1.1

Local Bundle PIDs

As a convention, descriptions starting with the bundle identity and a dot (.) are reserved for a bundle. As an example, a PID of "65.536" would belong to the bundle with a bundle identity of 65.

104.3.1.2

Software PIDs

Configuration target services that are singletons can use a Java package name they own as the PID (the reverse domain name scheme) as long as they do not use characters outside the basic ASCII set. As an example, the PID named com.acme.watchdog would represent a Watchdog service from the ACME company.

104.3.1.3

Devices

Devices are usually organized on buses or networks. The identity of a device, such as a unique serial number or an address, is a good component of a PID. The format of the serial number should be the same as that printed on the housing or box, to aid in recognition.

Table 11

Schemes for Device-Oriented PID Names

Bus	Example	Format	Description
USB	USB.0123-0002-9909873	idVendor (hex 4) idProduct (hex 4) iSerialNumber (decimal)	Universal Serial Bus. Use the standard device descriptor.
IP	IP.172.16.28.21	IP nr (dotted decimal)	Internet Protocol
802	802-00:60:97:00:9A:56	MAC address with: separators	IEEE 802 MAC address (Token Ring, Ethernet, ...)
ONE	ONE.06-00000021E461	Family (hex 2) and serial number including CRC (hex 6)	1-wire bus of Dallas Semiconductor
COM	COM.krups-brewer-12323	serial number or type name of device	Serial ports

104.4

The Configuration Object

A Configuration object contains the configuration dictionary, which is a set of properties that configure an aspect of a bundle. A bundle can receive Configuration objects by registering a configuration target service with a PID service property. See *The Persistent Identity* on page 67 for more information about PIDs.

During registration, the Configuration Admin service must detect these configuration target services and hand over their configuration dictionary via a callback. If this configuration dictionary is subsequently modified, the modified dictionary is handed over to the configuration target again with the same callback.

The Configuration object is primarily a set of properties that can be updated by a Management Agent, user interfaces on the OSGi Service Platform, or other applications. Configuration changes are first made persistent, and then passed to the target service via a call to the updated method in the `ManagedServiceFactory` or `ManagedService` class.

A Configuration object must be uniquely bound to a Managed Service or Managed Service Factory. This implies that a bundle must not register a Managed Service Factory with a PID that is the same as the PID given to a Managed Service.

104.4.1 Location Binding

When a Configuration object is created by either `getConfiguration` or `createFactoryConfiguration`, it becomes bound to the location of the calling bundle. This location is obtained with the associated bundle's `getLocation` method.

Location binding is a security feature that assures that only management bundles can modify configuration data, and other bundles can only modify their own configuration data. A `SecurityException` is thrown if a bundle other than a Management Agent bundle attempts to modify the configuration information of another bundle.

If a Managed Service is registered with a PID that is already bound to another location, the normal callback to `ManagedService.updated` must not take place.

The two argument versions of `getConfiguration` and `createFactoryConfiguration` take a location String as their second argument. These methods require the correct permission, and they create Configuration objects bound to the specified location, instead of the location of the calling bundle. These methods are intended for management bundles.

The creation of a Configuration object does not in itself initiate a callback to the target.

A null location parameter may be used to create Configuration objects that are not bound. In this case, the objects become bound to a specific location the first time that they are used by a bundle. When this dynamically bound bundle is subsequently uninstalled, the Configuration object's bundle location must be set to null again so it can be bound again later.

A management bundle may create a Configuration object before the associated Managed Service is registered. It may use a null location to avoid any dependency on the actual location of the bundle which registers this service. When the Managed Service is registered later, the Configuration object must be bound to the location of the registering bundle, and its configuration dictionary must then be passed to `ManagedService.updated`.

104.4.2 Configuration Properties

A configuration dictionary contains a set of properties in a Dictionary object. The value of the property may be of the following types:

```

type      ::= simple | vector | arrays

simple     ::= String | Integer | Long | Float | Double
           | Byte | Short | Character | Boolean

primitive ::= long | int | short | char | byte | double
           | float | boolean

arrays    ::= primitive '[' ']' | simple '[' ']'

vector    ::= Vector of simple

```

The name or key of a property must always be a String object, and is not case sensitive during look up, but must preserve the original case. The format of a property name must be:

```
property-name ::= symbolic-name // See 1.4.2
```

Properties can be used in other subsystems that have restrictions on the character set that can be used. The symbolic-name production uses a very minimal character set.

Bundles must not use nested vectors or arrays, nor must they use mixed types. Using mixed types or nesting makes it impossible to use the meta typing specification. See *Metatype Service Specification* on page 129.

104.4.3 Property Propagation

An implementation of a Managed Service should copy all the properties of the Dictionary object given in `updated(Dictionary)`, known or unknown, into its service registration properties using `ServiceRegistration.setProperties`.

This propagation allows the development of applications that leverage the Framework service registry more extensively, so compliance with this mechanism is advised.

A configuration target service may ignore any configuration properties it does not recognize, or it may change the values of the configuration properties before these properties are registered. Configuration properties in the Framework service registry are not strictly related to the configuration information.

Bundles that cooperate with the propagation of configuration properties can participate in horizontal applications. For example, an application that maintains physical location information in the Framework service registry could find out where a particular device is located in the house or car. This service could use a property dedicated to the physical location and provide functions that leverage this property, such as a graphic user interface that displays these locations.

104.4.4 Automatic Properties

The Configuration Admin service must automatically add a number of properties to the configuration dictionary. If these properties are also set by a configuring bundle or a plug-in, they must always be overridden before they are given to the target service. See *Configuration Plugin* on page 83. Therefore, the receiving bundle or plug-in can assume that the following properties are defined by the Configuration Admin service and not by the configuring bundle:

- `service.pid` – Set to the PID of the associated Configuration object.
- `service.factoryPid` – Only set for a Managed Service Factory. It is then set to the PID of the associated Managed Service Factory.
- `service.bundleLocation` – Set to the location of the bundle that can use this Configuration object. This property can only be used for searching, it may not appear in the configuration dictionary returned from the `getProperties` method due to security reasons, nor may it be used when the target is updated.

Constants for some of these properties can be found in `org.osgi.framework.Constants`. These system properties are all of type `String`.

104.4.5 Equality

Two different Configuration objects can actually represent the same underlying configuration. This means that a Configuration object must implement the `equals` and `hashCode` methods in such a way that two Configuration objects are equal when their PID is equal.

104.5 Managed Service

A Managed Service is used by a bundle that needs one configuration dictionary and is thus associated with one Configuration object in the Configuration Admin service.

A bundle can register any number of `ManagedService` objects, but each must be identified with its own PID.

A bundle should use a Managed Service when it needs configuration information for the following:

- *A Singleton* – A single entity in the bundle that needs to be configured.
- *Externally Detected Devices* – Each device that is detected causes a registration of an associated `ManagedService` object. The PID of this object is related to the identity of the device, such as the address or serial number.

104.5.1 Singletons

When an object must be instantiated only once, it is called a *singleton*. A singleton requires a single configuration dictionary. Bundles may implement several different types of singletons if necessary.

For example, a Watchdog service could watch the registry for the status and presence of services in the Framework service registry. Only one instance of a Watchdog service is needed, so only a single configuration dictionary is required that contains the polling time and the list of services to watch.

104.5.2 Networks

When a device in the external world needs to be represented in the OSGi Environment, it must be detected in some manner. The Configuration Admin service cannot know the identity and the number of instances of the device without assistance. When a device is detected, it still needs configuration information in order to play a useful role.

For example, a 1-Wire network can automatically detect devices that are attached and removed. When it detects a temperature sensor, it could register a Sensor service with the Framework service registry. This Sensor service needs configuration information specifically for that sensor, such as which lamps should be turned on, at what temperature the sensor is triggered, what timer should be started, in what zone it resides, and so on. One bundle could potentially have hundreds of these sensors and actuators, and each needs its own configuration information.

Each of these Sensor services should be registered as a Managed Service with a PID related to the physical sensor (such as the address) to receive configuration information.

Other examples are services discovered on networks with protocols like Jini, UPnP, and Salutation. They can usually be represented in the Framework service registry. A network printer, for example, could be detected via UPnP. Once in the service registry, these services usually require local configuration information. A Printer service needs to be configured for its local role: location, access list, and so on.

This information needs to be available in the Framework service registry whenever that particular Printer service is registered. Therefore, the Configuration Admin service must remember the configuration information for this Printer service.

This type of service should register with the Framework as a Managed Service in order to receive appropriate configuration information.

104.5.3 Configuring Managed Services

A bundle that needs configuration information should register one or more ManagedService objects with a PID service property. If it has a default set of properties for its configuration, it may include them as service properties of the Managed Service. These properties may be used as a configuration template when a Configuration object is created for the first time. A Managed Service optionally implements the MetaTypeProvider interface to provide information about the property types. See *Meta Typing* on page 87.

When this registration is detected by the Configuration Admin service, the following steps must occur:

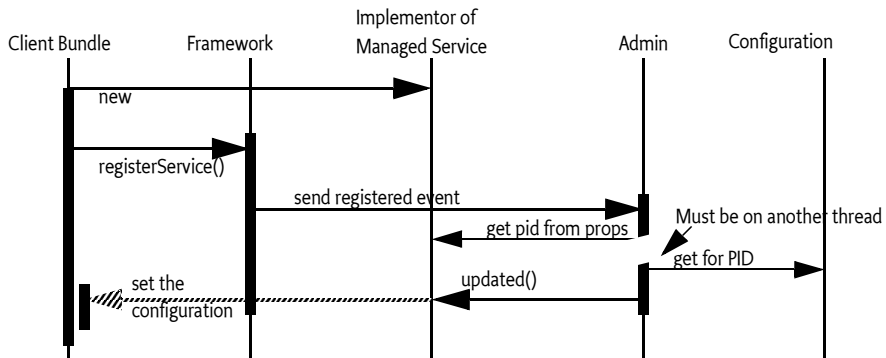
- The configuration stored for the registered PID must be retrieved. If there is a Configuration object for this PID, it is sent to the Managed Service with [updated\(Dictionary\)](#).

- If a Managed Service is registered and no configuration information is available, the Configuration Admin service must call `updated(Dictionary)` with a null parameter.
- If the Configuration Admin service starts *after* a Managed Service is registered, it must call `updated(Dictionary)` on this service as soon as possible. For this reason, a Managed Service must always get a callback when it registers *and* the Configuration Admin service is started.
- A Configuration Event `CM_UPDATED` is send asynchronously out to all registered Configuration Listener services.

The `updated(Dictionary)` callback from the Configuration Admin service to the Managed Service must take place asynchronously. This requirement allows the Managed Service to finish its initialization in a synchronized method without interference from the Configuration Admin service callback.

Care should be taken not to cause deadlocks by calling the Framework within a synchronized method.

Figure 16 Managed Service Configuration Action Diagram



The `updated` method may throw a [ConfigurationException](#). This object must describe the problem and what property caused the exception.

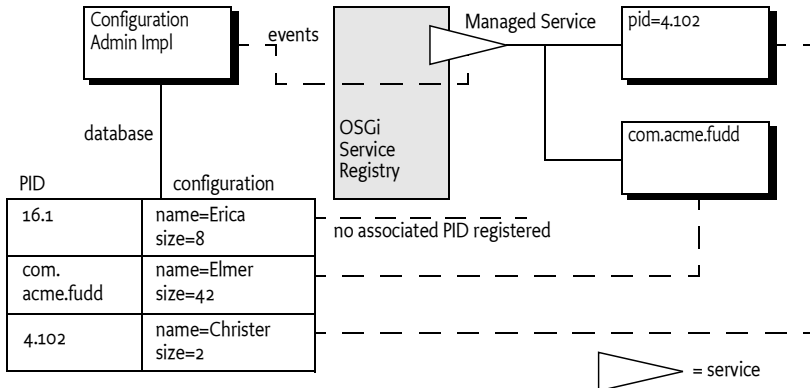
104.5.4 Race Conditions

When a Managed Service is registered, the default properties may be visible in the service registry for a short period before they are replaced by the properties of the actual configuration dictionary. Care should be taken that this visibility does not cause race conditions for other bundles.

In cases where race conditions could be harmful, the Managed Service must be split into two pieces: an object performing the actual service and a Managed Service. First, the Managed Service is registered, the configuration is received, and the actual service object is registered. In such cases, the use of a Managed Service Factory that performs this function should be considered.

104.5.5 Examples of Managed Service

Figure 17 shows a Managed Service configuration example. Two services are registered under the `ManagedService` interface, each with a different PID.

Figure 17 *PIDs and External Associations*

The Configuration Admin service has a database containing a configuration record for each PID. When the Managed Service with service.pid = com.acme.fudd is registered, the Configuration Admin service will retrieve the properties name=Elmer and size=42 from its database. The properties are stored in a Dictionary object and then given to the Managed Service with the updated(Dictionary) method.

104.5.5.1 **Configuring A Console Bundle**

In this example, a bundle can run a single debugging console over a Telnet connection. It is a singleton, so it uses a ManagedService object to get its configuration information: the port and the network name on which it should register.

```
class SampleManagedService implements ManagedService {
    Dictionary          properties;
    ServiceRegistration  registration;
    Console              console;

    public synchronized void start(
        BundleContext context ) throws Exception {
        properties = new Hashtable();
        properties.put( Constants.SERVICE_PID,
            "com.acme.console" );
        properties.put( "port",  new Integer(2011) );

        registration = context.registerService(
            ManagedService.class.getName(),
            this,
            properties
        );
    }

    public synchronized void updated( Dictionary np ) {
        if ( np != null ) {
            properties = np;
            properties.put(
```

```

        Constants.SERVICE_PID, "com.acme.console" );
    }

    if (console == null)
        console = new Console();

    int port = ((Integer)properties.get("port"))
        .intValue();

    String network = (String) properties.get("network");
    console.setPort(port, network);
    registration.setProperties(properties);
}
... further methods
}

```

104.5.6**Deletion**

When a Configuration object for a Managed Service is deleted, the Configuration Admin service must call `updated(Dictionary)` with a null argument on a thread that is different from that on which the `Configuration.delete` was executed. This deletion must send out a Configuration Event `CM_DELETED` to any registered Configuration Listener services after the `updated` method is called with a null.

104.6**Managed Service Factory**

A Managed Service Factory is used when configuration information is needed for a service that can be instantiated multiple times. When a Managed Service Factory is registered with the Framework, the Configuration Admin service consults its database and calls [updated\(String,Dictionary\)](#) for each associated Configuration object. It passes the identifier of the instance, which can be used as a PID, as well as a Dictionary object with the configuration properties.

A Managed Service Factory is useful when the bundle can provide functionality a number of times, each time with different configuration dictionaries. In this situation, the Managed Service Factory acts like a *class* and the Configuration Admin service can use this Managed Service Factory to *instantiate instances* for that *class*.

In the next section, the word *factory* refers to this concept of creating *instances* of a function defined by a bundle that registers a Managed Service Factory.

104.6.1**When to Use a Managed Service Factory**

A Managed Service Factory should be used when a bundle does not have an internal or external entity associated with the configuration information but can potentially be instantiated multiple times.

104.6.1.1**Example Email Fetcher**

An email fetcher program displays the number of emails that a user has – a function likely to be required for different users. This function could be viewed as a *class* that needs to be *instantiated* for each user. Each instance requires different parameters, including password, host, protocol, user id, and so on.

An implementation of the Email Fetcher service should register a ManagedServiceFactory object. In this way, the Configuration Admin service can define the configuration information for each user separately. The Email Fetcher service will only receive a configuration dictionary for each required instance (user).

104.6.1.2**Example Temperature Conversion Service**

Assume a bundle has the code to implement a conversion service that receives a temperature and, depending on settings, can turn an actuator on and off. This service would need to be instantiated many times depending on where it is needed. Each instance would require its own configuration information for the following:

- Upper value
- Lower value
- Switch Identification
- ...

Such a conversion service should register a service object under a ManagedServiceFactory interface. A configuration program can then use this Managed Service Factory to create instances as needed. For example, this program could use a Graphic User Interface (GUI) to create such a component and configure it.

104.6.1.3**Serial Ports**

Serial ports cannot always be used by the OSGi Device Access specification implementations. Some environments have no means to identify available serial ports, and a device on a serial port cannot always provide information about its type.

Therefore, each serial port requires a description of the device that is connected. The bundle managing the serial ports would need to instantiate a number of serial ports under the control of the Configuration Admin service, with the appropriate DEVICE_CATEGORY property to allow it to participate in the Device Access implementation.

If the bundle cannot detect the available serial ports automatically, it should register a Managed Service Factory. The Configuration Admin service can then, with the help of a configuration program, define configuration information for each available serial port.

104.6.2**Registration**

Similar to the Managed Service configuration dictionary, the configuration dictionary for a Managed Service Factory is identified by a PID. The Managed Service Factory, however, also has a *factory* PID, which is the PID of the associated Managed Service Factory. It is used to group all Managed Service Factory configuration dictionaries together.

When a Configuration object for a Managed Service Factory is created (ConfigurationAdmin.createFactoryConfiguration), a new unique PID is created for this object by the Configuration Admin service. The scheme used for this PID is defined by the Configuration Admin service and is unrelated to the factory PID.

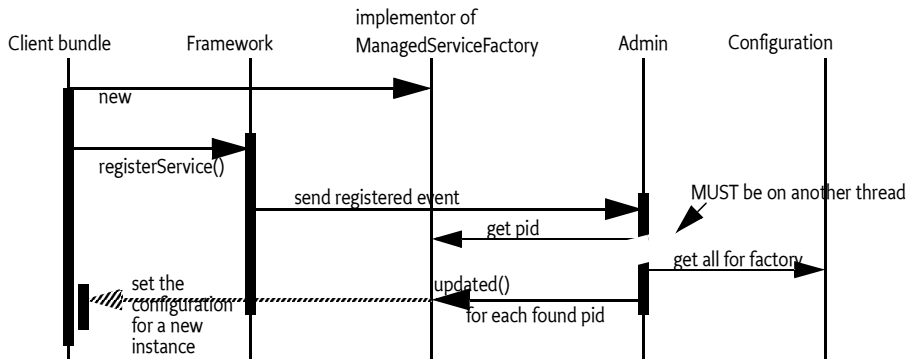
When the Configuration Admin service detects the registration of a Managed Service Factory, it must find all configuration dictionaries for this factory and must then sequentially call ManagedServiceFactory.updated(String,Dictionary) for each configuration dictionary. The first argument is the PID of the Configuration object (the one created by the Configuration Admin service) and the second argument contains the configuration properties.

The Managed Service Factory should then create any artifacts associated with that factory. Using the PID given in the Configuration object, the bundle may register new services (other than a Managed Service) with the Framework, but this is not required. This may be necessary when the PID is useful in contexts other than the Configuration Admin service.

The receiver must *not* register a Managed Service with this PID because this would force two Configuration objects to have the same PID. If a bundle attempts to do this, the Configuration Admin service should log an error and must ignore the registration of the Managed Service.

The Configuration Admin service must guarantee that no race conditions exist between initialization, updates, and deletions.

Figure 18 Managed Service Factory Action Diagram



A Managed Service Factory has only one update method: updated(String, Dictionary). This method can be called any number of times as Configuration objects are created or updated.

The Managed Service Factory must detect whether a PID is being used for the first time, in which case it should create a new *instance*, or a subsequent time, in which case it should update an existing instance.

The Configuration Admin service must call updated(String,Dictionary) on a thread that is different from the one that executed the registration. This requirement allows an implementation of a Managed Service Factory to use a synchronized method to assure that the callbacks do not interfere with the Managed Service Factory registration.

The `updated(String,Dictionary)` method may throw a [ConfigurationException](#) object. This object describes the problem and what property caused the problem. These exceptions should be logged by a Configuration Admin service.

104.6.3 Deletion

If a configuring bundle deletes an instance of a Managed Service Factory, the [deleted\(String\)](#) method is called. The argument is the PID for this instance. The implementation of the Managed Service Factory must remove all information and stop any behavior associated with that PID. If a service was registered for this PID, it should be unregistered.

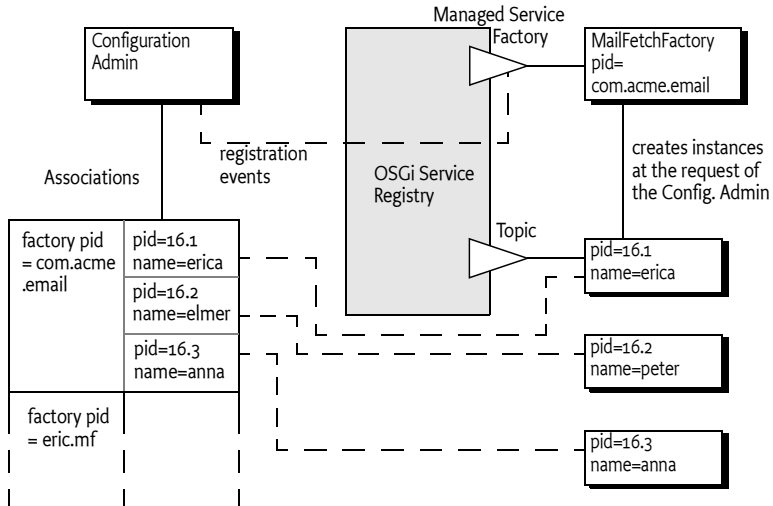
Deletion will asynchronously send out a Configuration Event `CM_DELETED` to all registered Configuration Listener services.

104.6.4 Managed Service Factory Example

Figure 19 highlights the differences between a Managed Service and a Managed Service Factory. It shows how a Managed Service Factory implementation receives configuration information that was created before it was registered.

- A bundle implements an EMail Fetcher service. It registers a `ManagedServiceFactory` object with `PID=com.acme.email`.
- The Configuration Admin service notices the registration and consults its database. It finds three Configuration objects for which the factory PID is equal to `com.acme.email`. It must call `updated(String,Dictionary)` for each of these Configuration objects on the newly registered `ManagedServiceFactory` object.
- For each configuration dictionary received, the factory should create a new instance of a `EMailFetcher` object, one for erica (`PID=16.1`), one for anna (`PID=16.3`), and one for elmer (`PID=16.2`).
- The `EMailFetcher` objects are registered under the Topic interface so their results can be viewed by an online display.
If the `EMailFetcher` object is registered, it may safely use the PID of the Configuration object because the Configuration Admin service must guarantee its suitability for this purpose.

Figure 19 Managed Service Factory Example



104.6.5 Multiple Consoles Example

This example illustrates how multiple consoles, each of which has its own port and interface can run simultaneously. This approach is very similar to the example for the Managed Service, but highlights the difference by allowing multiple consoles to be created.

```
class ExampleFactory implements ManagedServiceFactory {
    Hashtable consoles = new Hashtable();
    BundleContext context;
    public void start( BundleContext context )
        throws Exception {
        this.context = context;
        Hashtable local = new Hashtable();
        local.put(Constants.SERVICE_PID, "com.acme.console");
        context.registerService(
            ManagedServiceFactory.class.getName(),
            this,
            local );
    }

    public void updated( String pid, Dictionary config ){
        Console console = (Console) consoles.get(pid);
        if (console == null) {
            console = new Console(context);
            consoles.put(pid, console);
        }

        int port = getInt(config, "port", 2011);
        String network = getString(
            config,
            "network",
            null /*all*/
        );
    }
}
```

```
    );  
    console.setPort(port, network);  
}  
  
public void deleted(String pid) {  
    Console console = (Console) consoles.get(pid);  
    if (console != null) {  
        consoles.remove(pid);  
        console.close();  
    }  
}  
}
```

104.7 Configuration Admin Service

The [ConfigurationAdmin](#) interface provides methods to maintain configuration data in an OSGi environment. This configuration information is defined by a number of Configuration objects associated with specific configuration targets. Configuration objects can be created, listed, modified, and deleted through this interface. Either a remote management system or the bundles configuring their own configuration information may perform these operations.

The ConfigurationAdmin interface has methods for creating and accessing Configuration objects for a Managed Service, as well as methods for managing new Configuration objects for a Managed Service Factory.

104.7.1 Creating a Managed Service Configuration Object

A bundle can create a new Managed Service Configuration object with ConfigurationAdmin.getConfiguration. No create method is offered because doing so could introduce race conditions between different bundles trying to create a Configuration object for the same Managed Service. The getConfiguration method must atomically create and persistently store an object if it does not yet exist.

Two variants of this method are:

- [getConfiguration\(String\)](#) – This method is used by a bundle with a given location to configure its *own* ManagedService objects. The argument specifies the PID of the targeted service.
- [getConfiguration\(String,String\)](#) – This method is used by a management bundle to configure *another* bundle. Therefore, this management bundle needs the right permission. The first argument is the PID and the second argument is the location identifier of the targeted ManagedService object.

All Configuration objects have a method, [getFactoryPid\(\)](#), which in this case must return null because the Configuration object is associated with a Managed Service.

Creating a new Configuration object must *not* initiate a callback to the Managed Service updated method.

104.7.2 Creating a Managed Service Factory Configuration Object

The `ConfigurationAdmin` class provides two methods to create a new instance of a Managed Service Factory:

- `createFactoryConfiguration(String)` – This method is used by a bundle with a given location to configure its own `ManagedServiceFactory` objects. The argument specifies the PID of the targeted `ManagedServiceFactory` object. This *factory PID* can be obtained from the returned `Configuration` object with the `getFactoryPid()` method.
- `createFactoryConfiguration(String,String)` – This method is used by a management bundle to configure another bundle's `ManagedServiceFactory` object. The first argument is the location identifier and the second is the PID of the targeted `ManagedServiceFactory` object. The *factory PID* can be obtained from the returned `Configuration` object with `getFactoryPid` method.

Creating a new factory configuration must *not* initiate a callback to the `Managed Service Factory updated` method until the properties are set in the `Configuration` object with the `update` method.

104.7.3 Accessing Existing Configurations

The existing set of `Configuration` objects can be listed with `listConfigurations(String)`. The argument is a `String` object with a filter expression. This filter expression has the same syntax as the `Framework Filter` class. For example:

```
(&(size=42) (service. factoryPid=*osgi*))
```

The filter function must use the properties of the `Configuration` objects and only return the ones that match the filter expression.

A single `Configuration` object is identified with a PID and can be obtained with `getConfiguration(String)`.

If the caller has the right permission, then all `Configuration` objects are eligible for search. In other cases, only `Configuration` objects bound to the calling bundle's location must be returned.

`null` is returned in both cases when an appropriate `Configuration` object cannot be found.

104.7.3.1 Updating a Configuration

The process of updating a `Configuration` object is the same for `Managed Services` and `Managed Service Factories`. First, `listConfigurations(String)` or `getConfiguration(String)` should be used to get a `Configuration` object. The properties can be obtained with `Configuration.getProperties`. When no update has occurred since this object was created, `getProperties` returns `null`.

New properties can be set by calling `Configuration.update`. The Configuration Admin service must first store the configuration information and then call a configuration target's updated method: either the `ManagedService.updated` or `ManagedServiceFactory.updated` method. If this target service is not registered, the fresh configuration information must be given to the target when the configuration target service registers.

The update method calls in Configuration objects are not executed synchronously with the related target service updated method. This method must be called asynchronously. The Configuration Admin service, however, must have updated the persistent storage before the update method returns.

The update method must also asynchronously send out a Configuration Event `CM_UPDATED` to all registered Configuration Listeners.

104.7.4 Deletion

A Configuration object that is no longer needed can be deleted with `Configuration.delete`, which removes the Configuration object from the database. The database must be updated before the target service updated method is called.

If the target service is a Managed Service Factory, the factory is informed of the deleted Configuration object by a call to `ManagedServiceFactory.deleted`. It should then remove the associated *instance*. The `ManagedServiceFactory.deleted` call must be done asynchronously with respect to `Configuration.delete`.

When a Configuration object of a Managed Service is deleted, `ManagedService.updated` is called with null for the properties argument. This method may be used for clean-up, to revert to default values, or to unregister a service.

The update method must also asynchronously send out a Configuration Event `CM_DELETED` to all registered Configuration Listeners.

104.7.5 Updating a Bundle's Own Configuration

The Configuration Admin service specification does not distinguish between updates via a Management Agent and a bundle updating its own configuration information (as defined by its location). Even if a bundle updates its own configuration information, the Configuration Admin service must callback the associated target service updated method.

As a rule, to update its own configuration, a bundle's user interface should *only* update the configuration information and never its internal structures directly. This rule has the advantage that the events, from the bundle implementation's perspective, appear similar for internal updates, remote management updates, and initialization.

104.8 Configuration Events

Configuration Admin can update interested parties of changes in its repository. The model is based on the white board pattern where a Configuration Listener service is registered with the service registry. The Configuration Listener service will receive [ConfigurationEvent](#) objects if important

changes take place. The Configuration Admin service must call the `ConfigurationListener.configurationEvent(ConfigurationEvent)` method with such an event. This method should be called asynchronously, and on another thread, than the call that caused the event. Configuration Events must be delivered in order for each listener as they are generated. That is, events can be delivered on multiple threads but this must not re-order the events for a specific listener.

The ConfigurationEvent object carries a factory PID (`getFactoryPid()`) and a PID (`getPid()`). If the factory PID is null, the event is related to a Managed Service Configuration object, else the event is related to a Managed Service Factory Configuration object.

The ConfigurationEvent object can deliver the following events from the `getType()` method:

- `CM_DELETED` – The Configuration object is deleted.
- `CM_UPDATED` – The Configuration object is updated or created.

The Configuration Event also carries the ServiceReference object of the Configuration Admin service that generated the event.

104.8.1

Event Admin Service and Configuration Change Events

Configuration events are delivered asynchronously. The topic of a configuration event must be:

```
org/osgi/service/cm/ConfigurationEvent/<event type>
```

Event type can be any of the following:

```
CM_UPDATED
CM_DELETED
```

The properties of a configuration event are:

- `cm.factoryPid` – (String) The factory PID of the associated Configuration object, if the target is a Managed Service Factory. Otherwise not set.
- `cm.pid` – (String) The PID of the associated Configuration object.
- `service` – (ServiceReference) The Service Reference of the Configuration Admin service.
- `service.id` – (Long) The Configuration Admin service's ID.
- `service.objectClass` – (String[]) The Configuration Admin service's object class (which must include `org.osgi.service.cm.ConfigurationAdmin`)
- `service.pid` – (String) The Configuration Admin service's persistent identity

104.9

Configuration Plugin

The Configuration Admin service allows third-party applications to participate in the configuration process. Bundles that register a service object under a `ConfigurationPlugin` interface can process the configuration dictionary just before it reaches the configuration target service.

Plug-ins allow sufficiently privileged bundles to intercept configuration dictionaries just *before* they must be passed to the intended Managed Service or Managed Service Factory but *after* the properties are stored. The changes the plug-in makes are dynamic and must not be stored. The plug-in must only be called when an update takes place while it is registered.

The ConfigurationPlugin interface has only one method: `modifyConfiguration(ServiceReference,Dictionary)`. This method inspects or modifies configuration data.

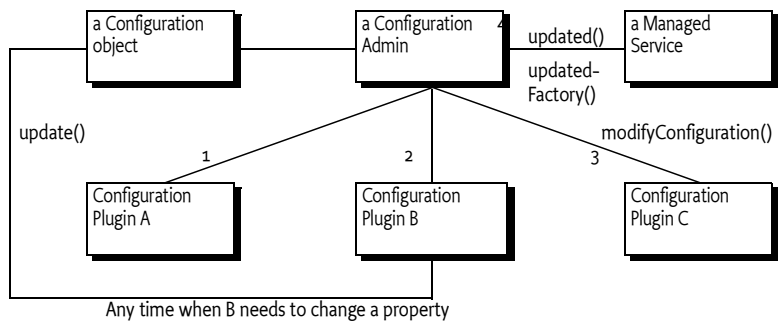
All plug-ins in the service registry must be traversed and called before the properties are passed to the configuration target service. Each Configuration Plugin object gets a chance to inspect the existing data, look at the target object, which can be a ManagedService object or a ManagedServiceFactory object, and modify the properties of the configuration dictionary. The changes made by a plug-in must be visible to plugins that are called later.

ConfigurationPlugin objects should not modify properties that belong to the configuration properties of the target service unless the implications are understood. This functionality is mainly intended to provide functions that leverage the Framework service registry. The changes made by the plugin should normally not be validated. However, the Configuration Admin must ignore changes to the automatic properties as described in *Automatic Properties* on page 71.

For example, a Configuration Plugin service may add a physical location property to a service. This property can be leveraged by applications that want to know where a service is physically located. This scenario could be carried out without any further support of the service itself, except for the general requirement that the service should propagate the properties it receives from the Configuration Admin service to the service registry.

Figure 20

Order of Configuration Plugin Services



104.9.1 Limiting The Targets

A ConfigurationPlugin object may optionally specify a `cm.target` registration property. This value is the PID of the configuration target whose configuration updates the ConfigurationPlugin object wants to intercept.

The ConfigurationPlugin object must then only be called with updates for the configuration target service with the specified PID. Omitting the `cm.target` registration property means that it is called for *all* configuration updates.

104.9.2 Example of Property Expansion

Consider a Managed Service that has a configuration property `service.to` with the value `(objectclass=com.acme.Alarm)`. When the Configuration Admin service sets this property on the target service, a `ConfigurationPlugin` object may replace the `(objectclass=com.acme.Alarm)` filter with an array of existing alarm systems' PIDs as follows:

```
ID "service.to=[32434,232,12421,1212]"
```

A new Alarm Service with `service.pid=343` is registered, requiring that the list of the target service be updated. The bundle which registered the `ConfigurationPlugin` service, therefore, wants to set the `to` registration property on the target service. It does *not* do this by calling `ManagedService.updated` directly for several reasons:

- In a securely configured system, it should not have the permission to make this call or even obtain the target service.
- It could get into race conditions with the Configuration Admin service if it had the permissions in the previous bullet. Both services would compete for access simultaneously.

Instead, it must get the Configuration object from the Configuration Admin service and call the update method on it.

The Configuration Admin service must schedule a new update cycle on another thread, and sometime in the future must call `ConfigurationPlugin.modifyProperties`. The `ConfigurationPlugin` object could then set the `service.to` property to `[32434,232,12421,1212, 343]`. After that, the Configuration Admin service must call `updated` on the target service with the new `service.to` list.

104.9.3 Configuration Data Modifications

Modifications to the configuration dictionary are still under the control of the Configuration Admin service, which must determine whether to accept the changes, hide critical variables, or deny the changes for other reasons.

The `ConfigurationPlugin` interface must also allow plugins to detect configuration updates to the service via the callback. This ability allows them to synchronize the configuration updates with transient information.

104.9.4 Forcing a Callback

If a bundle needs to force a Configuration Plugin service to be called again, it must fetch the appropriate Configuration object from the Configuration Admin service and call the `update()` method (the no parameter version) on this object. This call forces an update with the current configuration dictionary so that all applicable plug-ins get called again.

104.9.5 **Calling Order**

The order in which the ConfigurationPlugin objects are called must depend on the service.cmRanking configuration property of the ConfigurationPlugin object. Table 12 shows the usage of the service.cmRanking property for the order of calling the Configuration Plugin services.

Table 12 service.cmRanking Usage For Ordering

service.cmRanking value	Description
< 0	The Configuration Plugin service should not modify properties and must be called before any modifications are made.
> 0 && <= 1000	The Configuration Plugin service modifies the configuration data. The calling order should be based on the value of the service.cmRanking property.
> 1000	The Configuration Plugin service should not modify data and is called after all modifications are made.

104.10 **Remote Management**

This specification does not attempt to define a remote management interface for the Framework. The purpose of this specification is to define a minimal interface for bundles that is complete enough for testing.

The Configuration Admin service is a primary aspect of remote management, however, and this specification must be compatible with common remote management standards. This section discusses some of the issues of using this specification with [16] *DMTF Common Information Model* (CIM) and [17] *Simple Network Management Protocol* (SNMP), the most likely candidates for remote management today.

These discussions are not complete, comprehensive, or normative. They are intended to point the bundle developer in relevant directions. Further specifications are needed to make a more concrete mapping.

104.10.1 **Common Information Model**

Common Information Model (CIM) defines the managed objects in [19] *Interface Definition Language* (IDL) language, which was developed for the Common Object Request Broker Architecture (CORBA).

The data types and the data values have a syntax. Additionally, these syntaxes can be mapped to XML. Unfortunately, this XML mapping is very different from the very applicable [18] *XSchema* XML data type definition language. The Framework service registry property types are a proper subset of the CIM data types.

In this specification, a Managed Service Factory maps to a CIM class definition. The primitives create, delete, and set are supported in this specification via the ManagedServiceFactory interface. The possible data types in CIM are richer than those the Framework supports and should thus be limited to cases when CIM classes for bundles are defined.

An important conceptual difference between this specification and CIM is the naming of properties. CIM properties are defined within the scope of a class. In this specification, properties are primarily defined within the scope of the Managed Service Factory, but are then placed in the registry, where they have global scope. This mechanism is similar to [20] *Lightweight Directory Access Protocol*, in which the semantics of the properties are defined globally and a class is a collection of globally defined properties.

This specification does not address the non-Configuration Admin service primitives such as notifications and method calls.

104.10.2 Simple Network Management Protocol

The Simple Network Management Protocol (SNMP) defines the data model in ASN.1. SNMP is a rich data typing language that supports many types that are difficult to map to the data types supported in this specification. A large overlap exists, however, and it should be possible to design a data type that is applicable in this context.

The PID of a Managed Service should map to the SNMP Object Identifier (OID). Managed Service Factories are mapped to tables in SNMP, although this mapping creates an obvious restriction in data types because tables can only contain scalar values. Therefore, the property values of the Configuration object would have to be limited to scalar values.

Similar scope issues as seen in CIM arise for SNMP because properties have a global scope in the service registry.

SNMP does not support the concept of method calls or function calls. All information is conveyed as the setting of values. The SNMP paradigm maps closely to this specification.

This specification does not address non-Configuration Admin primitives such as traps.

104.11 Meta Typing

This section discusses how the Metatype specification is used in the context of a Configuration Admin service.

When a Managed Service or Managed Service Factory is registered, the service object may also implement the `MetaTypeProvider` interface.

If the Managed Service or Managed Service Factory object implements the `MetaTypeProvider` interface, a management bundle may assume that the associated `ObjectClassDefinition` object can be used to configure the service.

The `ObjectClassDefinition` and `AttributeDefinition` objects contain sufficient information to automatically build simple user interfaces. They can also be used to augment dedicated interfaces with accurate validations.

When the Metatype specification is used, care should be taken to match the capabilities of the metatype package to the capabilities of the Configuration Admin service specification. Specifically:

- The metatype specification must describe nested arrays and vectors or arrays/vectors of mixed type.

This specification does not address how the metatype is made available to a management system due to the many open issues regarding remote management.

104.12 Security

104.12.1 Configuration Permission

The Configuration Permission provides a bundle with the authority to configure other bundles. All bundles implicitly have the permission to manage configurations that are bound to their own location.

The Configure Permission has only a single action and the target must always be *. The action is:

- **CONFIGURE** – This action grants a bundle the authority to manage configurations for any other bundle.

The * wildcard for the actions parameter is supported.

104.12.2 Permissions Summary

Configuration Admin service security is implemented using Service Permission and Configuration Permission. The following table summarizes the permissions needed by the Configuration Admin bundle itself, as well as the typical permissions needed by the bundles with which it interacts.

Configuration Admin:

```
ServicePermission[ ..ConfigurationAdmin, REGISTER ]
ServicePermission[ ..ManagedService, GET ]
ServicePermission[ ..ManagedServiceFactory, GET ]
ServicePermission[ ..ConfigurationPlugin, GET ]
ConfigurationPermission[ *, CONFIGURE ]
AdminPermission[ *, METADATA ]
```

Managed Service:

```
ServicePermission[ ..ConfigurationAdmin, GET ]
ServicePermission[ ..ManagedService, REGISTER ]
```

Managed Service Factory:

```
ServicePermission[ ..ConfigurationAdmin, GET ]
ServicePermission[ ..ManagedServiceFactory, REGISTER ]
```

Configuration Plugin:

```
ServicePermission[ ..ConfigurationPlugin, REGISTER ]
```

Configuration Listener:

```
ServicePermission[ ..ConfigurationListener, REGISTER ]
```

The Configuration Admin service must have `ServicePermission[ConfigurationAdmin, REGISTER]`. It will also be the only bundle that needs the `ServicePermission[ManagedService | ManagedServiceFactory | ConfigurationPlugin, GET]`. No other bundle should be allowed to have GET permission for these interfaces. The Configuration Admin bundle must also hold `ConfigurationPermission[*, CONFIGURE]`.

Bundles that can be configured must have the `ServicePermission[ManagedService | ManagedServiceFactory, REGISTER]`. Bundles registering `ConfigurationPlugin` objects must have `ServicePermission[ConfigurationPlugin, REGISTER]`. The Configuration Admin service must trust all services registered with the `ConfigurationPlugin` interface. Only the Configuration Admin service should have `ServicePermission[ConfigurationPlugin, GET]`.

If a Managed Service or Managed Service Factory is implemented by an object that is also registered under another interface, it is possible, although inappropriate, for a bundle other than the Configuration Admin service implementation to call the updated method. Security-aware bundles can avoid this problem by having their updated methods check that the caller has `ConfigurationPermission[*, CONFIGURE]`.

Bundles that want to change their own configuration need `ServicePermission[ConfigurationAdmin, GET]`. A bundle with `ConfigurationPermission[*, CONFIGURE]` is allowed to access and modify any Configuration object.

Pre-configuration of bundles requires `ConfigurationPermission[*, CONFIGURE]` because the methods that specify a location require this permission.

104.12.3 Forging PIDs

A risk exists of an unauthorized bundle forging a PID in order to obtain and possibly modify the configuration information of another bundle. To mitigate this risk, Configuration objects are generally *bound* to a specific bundle location, and are not passed to any Managed Service or Managed Service Factory registered by a different bundle.

Bundles with the required permission can create Configuration objects that are not bound. In other words, they have their location set to null. This can be useful for pre-configuring bundles before they are installed without having to know their actual locations.

In this scenario, the Configuration object must become bound to the first bundle that registers a Managed Service (or Managed Service Factory) with the right PID.

A bundle could still possibly obtain another bundle's configuration by registering a Managed Service with the right PID before the victim bundle does so. This situation can be regarded as a denial-of-service attack, because the victim bundle would never receive its configuration information. Such an attack can be avoided by always binding Configuration objects to the right locations. It can also be detected by the Configuration Admin service when the victim bundle registers the correct PID and two equal PIDs are then registered. This violation of this specification should be logged.

104.12.4**Configuration and Permission Administration**

Configuration information has a direct influence on the permissions needed by a bundle. For example, when the Configuration Admin Bundle orders a bundle to use port 2011 for a console, that bundle also needs permission for listening to incoming connections on that port.

Both a simple and a complex solution exist for this situation.

The simple solution for this situation provides the bundle with a set of permissions that do not define specific values but allow a range of values. For example, a bundle could listen to ports above 1024 freely. All these ports could then be used for configuration.

The other solution is more complicated. In an environment where there is very strong security, the bundle would only be allowed access to a specific port. This situation requires an atomic update of both the configuration data and the permissions. If this update was not atomic, a potential security hole would exist during the period of time that the set of permissions did not match the configuration.

The following scenario can be used to update a configuration and the security permissions:

- 1 Stop the bundle.
- 2 Update the appropriate Configuration object via the Configuration Admin service.
- 3 Update the permissions in the Framework.
- 4 Start the bundle.

This scenario would achieve atomicity from the point of view of the bundle.

104.13**Configurable Service**

Both the Configuration Admin service and the `org.osgi.framework.Configurable` interface address configuration management issues. It is the intention of this specification to replace the Framework interface for configuration management.

The Framework Configurable mechanism works as follows. A registered service object implements the Configurable interface to allow a management bundle to configure that service. The Configurable interface has only one method: `getConfigurationObject()`. This method returns a Java Bean. Beans can be examined and modified with the `java.reflect` or `java.bean` packages.

This scheme has the following disadvantages:

- *No factory* – Only registered services can be configured, unlike the Managed Service Factory that configures any number of services.
- *Atomicity* – The beans or reflection API can only modify one property at a time and there is no way to tell the bean that no more modifications to the properties will follow. This limitation complicates updates of configurations that have dependencies between properties. This specification passes a Dictionary object that sets all the configuration properties atomically.

- *Profile* – The Java beans API is linked to many packages that are not likely to be present in OSGi environments. The reflection API may be present but is not simple to use.
This specification has no required libraries.
- *User Interface support* – UI support in beans is very rudimentary when no AWT is present.
The associated Metatyping specification does not require any external libraries, and has extensive support for UIs including localization.

104.14 Changes

- Added a Configuration Listener service that receives the Configuration Admin key events. See *Configuration Events* on page 82.
- Added a new ConfigurationPermission class which replaces the use of Admin Permission. So bundles which run with this version of Configuration Admin must be deployed with the necessary Configuration Permissions rather than Admin Permission. See *Configuration Permission* on page 88.
- The PID is now defined in the Core specification as well
- A property name is now defined as a unique-name.
- Event Admin mapping added.

104.15 org.osgi.service.cm

The OSGi Configuration Admin service Package. Specification Version 1.2

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.service.cm; version=1.2

104.15.1 Summary

- Configuration - The configuration information for a ManagedService or ManagedServiceFactory object. [p.91]
- ConfigurationAdmin - Service for administering configuration data. [p.94]
- ConfigurationEvent - A Configuration Event. [p.97]
- ConfigurationException - An Exception class to inform the Configuration Admin service of problems with configuration data. [p.99]
- ConfigurationListener - Listener for Configuration Events. [p.100]
- ConfigurationPermission - Indicates a bundle's authority to configure bundles. [p.100]
- ConfigurationPlugin - A service interface for processing configuration dictionary before the update. [p.101]
- ManagedService - A service that can receive configuration data from a Configuration Admin service. [p.103]
- ManagedServiceFactory - Manage multiple service instances. [p.104]

104.15.2 public interface Configuration

The configuration information for a ManagedService or ManagedServiceFactory object. The Configuration Admin service uses this interface to represent the configuration information for a ManagedService or for a service instance of a ManagedServiceFactory.

A Configuration object contains a configuration dictionary and allows the properties to be updated via this object. Bundles wishing to receive configuration dictionaries do not need to use this class - they register a ManagedService or ManagedServiceFactory. Only administrative bundles, and bundles wishing to update their own configurations need to use this class.

The properties handled in this configuration have case insensitive String objects as keys. However, case is preserved from the last set key/value.

A configuration can be *bound* to a bundle location (Bundle.getLocation()). The purpose of binding a Configuration object to a location is to make it impossible for another bundle to forge a PID that would match this configuration. When a configuration is bound to a specific location, and a bundle with a different location registers a corresponding ManagedService object or ManagedServiceFactory object, then the configuration is not passed to the updated method of that object.

If a configuration's location is null, it is not yet bound to a location. It will become bound to the location of the first bundle that registers a ManagedService or ManagedServiceFactory object with the corresponding PID.

The same Configuration object is used for configuring both a Managed Service Factory and a Managed Service. When it is important to differentiate between these two the term "factory configuration" is used.

104.15.2.1 public void delete() throws IOException

- Delete this Configuration object. Removes this configuration object from the persistent store. Notify asynchronously the corresponding Managed Service or Managed Service Factory. A ManagedService object is notified by a call to its updated method with a null properties argument. A ManagedServiceFactory object is notified by a call to its deleted method.

Also initiates an asynchronous call to all ConfigurationListeners with a ConfigurationEvent.CM_DELETED event.

Throws IOException – If delete fails

IllegalStateException – if this configuration has been deleted

104.15.2.2 public boolean equals(Object other)

other Configuration object to compare against

- Equality is defined to have equal PIDs Two Configuration objects are equal when their PIDs are equal.

Returns true if equal, false if not a Configuration object or one with a different PID.

104.15.2.3 public String getBundleLocation()

- Get the bundle location. Returns the bundle location to which this configuration is bound, or null if it is not yet bound to a bundle location.

Returns location to which this configuration is bound, or null.

Throws `IllegalStateException` – If this Configuration object has been deleted.
`SecurityException` – If the caller does not have `ConfigurationPermission[*CONFIGURE]`.

104.15.2.4 `public String getFactoryPid()`

- For a factory configuration return the PID of the corresponding Managed Service Factory, else return null.

Returns factory PID or null

Throws `IllegalStateException` – if this configuration has been deleted

104.15.2.5 `public String getPid()`

- Get the PID for this Configuration object.

Returns the PID for this Configuration object.

Throws `IllegalStateException` – if this configuration has been deleted

104.15.2.6 `public Dictionary getProperties()`

- Return the properties of this Configuration object. The Dictionary object returned is a private copy for the caller and may be changed without influencing the stored configuration. The keys in the returned dictionary are case insensitive and are always of type `String`.

If called just after the configuration is created and before update has been called, this method returns null.

Returns A private copy of the properties for the caller or null. These properties must not contain the “service.bundleLocation” property. The value of this property may be obtained from the `getBundleLocation` method.

Throws `IllegalStateException` – if this configuration has been deleted

104.15.2.7 `public int hashCode()`

- Hash code is based on PID. The hashcode for two Configuration objects must be the same when the Configuration PID's are the same.

Returns hash code for this Configuration object

104.15.2.8 `public void setBundleLocation(String bundleLocation)`

bundleLocation a bundle location or null

- Bind this Configuration object to the specified bundle location. If the `bundleLocation` parameter is null then the Configuration object will not be bound to a location. It will be set to the bundle's location before the first time a Managed Service/Managed Service Factory receives this Configuration object via the `update` method and before any plugins are called. The bundle location will be set persistently.

Throws `IllegalStateException` – If this configuration has been deleted.

`SecurityException` – If the caller does not have `ConfigurationPermission[*CONFIGURE]`.

104.15.2.9 `public void update(Dictionary properties) throws IOException`

properties the new set of properties for this configuration

- Update the properties of this Configuration object. Stores the properties in persistent storage after adding or overwriting the following properties:
 - “service.pid”: is set to be the PID of this configuration.
 - “service.factoryPid”: if this is a factory configuration it is set to the factory PID else it is not set.

These system properties are all of type String.

If the corresponding Managed Service/Managed Service Factory is registered, its updated method must be called asynchronously. Else, this callback is delayed until aforementioned registration occurs.

Also initiates an asynchronous call to all ConfigurationListeners with a ConfigurationEvent.CM_UPDATED event.

Throws IOException – if update cannot be made persistent

IllegalArgumentException – if the Dictionary object contains invalid configuration types or contains case variants of the same key name.

IllegalStateException – if this configuration has been deleted

104.15.2.10 **public void update() throws IOException**

- Update the Configuration object with the current properties. Initiate the updated callback to the Managed Service or Managed Service Factory with the current properties asynchronously.

This is the only way for a bundle that uses a Configuration Plugin service to initiate a callback. For example, when that bundle detects a change that requires an update of the Managed Service or Managed Service Factory via its ConfigurationPlugin object.

Throws IOException – if update cannot access the properties in persistent storage

IllegalStateException – if this configuration has been deleted

See Also ConfigurationPlugin[p.101]

104.15.3 **public interface ConfigurationAdmin**

Service for administering configuration data.

The main purpose of this interface is to store bundle configuration data persistently. This information is represented in Configuration objects. The actual configuration data is a Dictionary of properties inside a Configuration object.

There are two principally different ways to manage configurations. First there is the concept of a Managed Service, where configuration data is uniquely associated with an object registered with the service registry.

Next, there is the concept of a factory where the Configuration Admin service will maintain 0 or more Configuration objects for a Managed Service Factory that is registered with the Framework.

The first concept is intended for configuration data about “things/services” whose existence is defined externally, e.g. a specific printer. Factories are intended for “things/services” that can be created any number of times, e.g. a configuration for a DHCP server for different networks.

Bundles that require configuration should register a Managed Service or a Managed Service Factory in the service registry. A registration property named `service.pid` (persistent identifier or PID) must be used to identify this Managed Service or Managed Service Factory to the Configuration Admin service.

When the ConfigurationAdmin detects the registration of a Managed Service, it checks its persistent storage for a configuration object whose PID matches the PID registration property (`service.pid`) of the Managed Service. If found, it calls `ManagedService.updated`[p.104] method with the new properties. The implementation of a Configuration Admin service must run these call-backs asynchronously to allow proper synchronization.

When the Configuration Admin service detects a Managed Service Factory registration, it checks its storage for configuration objects whose `factoryPid` matches the PID of the Managed Service Factory. For each such Configuration objects, it calls the `ManagedServiceFactory.updated` method asynchronously with the new properties. The calls to the `updated` method of a `ManagedServiceFactory` must be executed sequentially and not overlap in time.

In general, bundles having permission to use the Configuration Admin service can only access and modify their own configuration information. Accessing or modifying the configuration of another bundle requires `ConfigurationPermission[*,CONFIGURE]`.

Configuration objects can be *bound* to a specified bundle location. In this case, if a matching Managed Service or Managed Service Factory is registered by a bundle with a different location, then the Configuration Admin service must not do the normal callback, and it should log an error. In the case where a Configuration object is not bound, its location field is null, the Configuration Admin service will bind it to the location of the bundle that registers the first Managed Service or Managed Service Factory that has a corresponding PID property. When a Configuration object is bound to a bundle location in this manner, the Configuration Admin service must detect if the bundle corresponding to the location is uninstalled. If this occurs, the Configuration object is unbound, that is its location field is set back to null.

The method descriptions of this class refer to a concept of “the calling bundle”. This is a loose way of referring to the bundle which obtained the Configuration Admin service from the service registry. Implementations of ConfigurationAdmin must use a `org.osgi.framework.ServiceFactory` to support this concept.

104.15.3.1

**public static final String SERVICE_BUNDLELOCATION =
“service.bundleLocation”**

Service property naming the location of the bundle that is associated with a Configuration object. This property can be searched for but must not appear in the configuration dictionary for security reason. The property’s value is of type String.

Since 1.1

104.15.3.2 **public static final String SERVICE_FACTORYPID = "service.factoryPid"**

Service property naming the Factory PID in the configuration dictionary.
The property's value is of type String.

Since 1.1

104.15.3.3 **public Configuration createFactoryConfiguration(String factoryPid)
throws IOException**

factoryPid PID of factory (not null).

- Create a new factory Configuration object with a new PID. The properties of the new Configuration object are null until the first time that its Configuration.update(Dictionary)[p.93] method is called.

It is not required that the factoryPid maps to a registered Managed Service Factory.

The Configuration object is bound to the location of the calling bundle.

Returns A new Configuration object.

Throws IOException – if access to persistent storage fails.

SecurityException – if caller does not have ConfigurationPermission[*, CONFIGURE] and factoryPid is bound to another bundle.

104.15.3.4 **public Configuration createFactoryConfiguration(String factoryPid,
String location) throws IOException**

factoryPid PID of factory (not null).

location A bundle location string, or null.

- Create a new factory Configuration object with a new PID. The properties of the new Configuration object are null until the first time that its Configuration.update(Dictionary)[p.93] method is called.

It is not required that the factoryPid maps to a registered Managed Service Factory.

The Configuration is bound to the location specified. If this location is null it will be bound to the location of the first bundle that registers a Managed Service Factory with a corresponding PID.

Returns a new Configuration object.

Throws IOException – if access to persistent storage fails.

SecurityException – if caller does not have ConfigurationPermission[*, CONFIGURE].

104.15.3.5 **public Configuration getConfiguration(String pid, String location)
throws IOException**

pid Persistent identifier.

location The bundle location string, or null.

- Get an existing Configuration object from the persistent store, or create a new Configuration object.

If a Configuration with this PID already exists in Configuration Admin service return it. The location parameter is ignored in this case.

Else, return a new Configuration object. This new object is bound to the location and the properties are set to null. If the location parameter is null, it will be set when a Managed Service with the corresponding PID is registered for the first time.

Returns An existing or new Configuration object.

Throws IOException – if access to persistent storage fails.

SecurityException – if the caller does not have ConfigurationPermission[*,CONFIGURE].

104.15.3.6 **public Configuration getConfiguration(String pid) throws IOException**

pid persistent identifier.

- Get an existing or new Configuration object from the persistent store. If the Configuration object for this PID does not exist, create a new Configuration object for that PID, where properties are null. Bind its location to the calling bundle's location.

Otherwise, if the location of the existing Configuration object is null, set it to the calling bundle's location.

Returns an existing or new Configuration matching the PID.

Throws IOException – if access to persistent storage fails.

SecurityException – if the Configuration object is bound to a location different from that of the calling bundle and it has no ConfigurationPermission[*,CONFIGURE].

104.15.3.7 **public Configuration[] listConfigurations(String filter) throws IOException, InvalidSyntaxException**

filter a Filter object, or null to retrieve all Configuration objects.

- List the current Configuration objects which match the filter.

Only Configuration objects with non- null properties are considered current. That is, Configuration.getProperties() is guaranteed not to return null for each of the returned Configuration objects.

Normally only Configuration objects that are bound to the location of the calling bundle are returned, or all if the caller has ConfigurationPermission[*,CONFIGURE].

The syntax of the filter string is as defined in the Filter class. The filter can test any configuration parameters including the following system properties:

- service.pid-String- the PID under which this is registered
- service.factoryPid-String- the factory if applicable
- service.bundleLocation-String- the bundle location

The filter can also be null, meaning that all Configuration objects should be returned.

Returns all matching Configuration objects, or null if there aren't any

Throws IOException – if access to persistent storage fails

InvalidSyntaxException – if the filter string is invalid

104.15.4 public class ConfigurationEvent

A Configuration Event.

ConfigurationEvent objects are delivered to all registered ConfigurationListener service objects. ConfigurationEvents must be asynchronously delivered in chronological order with respect to each listener.

A type code is used to identify the type of event. The following event types are defined:

- CM_UPDATED[p.98]
- CM_DELETED[p.98]

Security Considerations. ConfigurationEvent objects do not provide Configuration objects, so no sensitive configuration information is available from the event. If the listener wants to locate the Configuration object for the specified pid, it must use ConfigurationAdmin.

See Also ConfigurationListener[p.100]

Since 1.2

104.15.4.1 public static final int CM_DELETED = 2

A Configuration has been deleted.

This ConfigurationEvent type that indicates that a Configuration object has been deleted. An event is fired when a call to Configuration.delete successfully deletes a configuration.

The value of CM_DELETED is 2.

104.15.4.2 public static final int CM_UPDATED = 1

A Configuration has been updated.

This ConfigurationEvent type that indicates that a Configuration object has been updated with new properties. An event is fired when a call to Configuration.update successfully changes a configuration.

The value of CM_UPDATED is 1.

104.15.4.3 public ConfigurationEvent(ServiceReference reference, int type, String factoryPid, String pid)

reference The ServiceReference object of the Configuration Admin service that created this event.

type The event type. See getType[p.99].

factoryPid The factory pid of the associated configuration if the target of the configuration is a ManagedServiceFactory. Otherwise null if the target of the configuration is a ManagedService.

pid The pid of the associated configuration.

- Constructs a ConfigurationEvent object from the given ServiceReference object, event type, and pids.

104.15.4.4 public String getFactoryPid()

- Returns the factory pid of the associated configuration.

Returns Returns the factory pid of the associated configuration if the target of the configuration is a ManagedServiceFactory. Otherwise null if the target of the configuration is a ManagedService.

104.15.4.5 public String getPid()

- ❑ Returns the pid of the associated configuration.

Returns Returns the pid of the associated configuration.

104.15.4.6 public ServiceReference getReference()

- ❑ Return the ServiceReference object of the Configuration Admin service that created this event.

Returns The ServiceReference object for the Configuration Admin service that created this event.

104.15.4.7 public int getType()

- ❑ Return the type of this event.

The type values are:

- CM_UPDATED[p.98]
- CM_DELETED[p.98]

Returns The type of this event.

104.15.5 public class ConfigurationException extends Exception

An Exception class to inform the Configuration Admin service of problems with configuration data.

104.15.5.1 public ConfigurationException(String property, String reason)

property name of the property that caused the problem, null if no specific property was the cause

reason reason for failure

- ❑ Create a ConfigurationException object.

104.15.5.2 public ConfigurationException(String property, String reason, Throwable cause)

property name of the property that caused the problem, null if no specific property was the cause

reason reason for failure

cause The cause of this exception.

- ❑ Create a ConfigurationException object.

Since 1.2

104.15.5.3 public Throwable getCause()

- ❑ Returns the cause of this exception or null if no cause was specified when this exception was created.

Returns The cause of this exception or null if no cause was specified.

Since 1.2

104.15.5.4 public String getProperty()

- ❑ Return the property name that caused the failure or null.

Returns name of property or null if no specific property caused the problem

104.15.5.5 public String getReason()

- ❑ Return the reason for this exception.

Returns reason of the failure

104.15.5.6 public Throwable initCause(Throwable cause)

cause Cause of the exception.

- ❑ The cause of this exception can only be set when constructed.

Returns This object.

Throws `IllegalStateException` – This method will always throw an `IllegalStateException` since the cause of this exception can only be set when constructed.

Since 1.2

104.15.6 public interface ConfigurationListener

Listener for Configuration Events. When a `ConfigurationEvent` is fired, it is asynchronously delivered to a `ConfigurationListener`.

`ConfigurationListener` objects are registered with the Framework service registry and are notified with a `ConfigurationEvent` object when an event is fired.

`ConfigurationListener` objects can inspect the received `ConfigurationEvent` object to determine its type, the pid of the `Configuration` object with which it is associated, and the `Configuration Admin` service that fired the event.

Security Considerations. Bundles wishing to monitor configuration events will require `ServicePermission[ConfigurationListener,REGISTER]` to register a `ConfigurationListener` service.

Since 1.2

104.15.6.1 public void configurationEvent(ConfigurationEvent event)

event The `ConfigurationEvent`.

- ❑ Receives notification of a `Configuration` that has changed.

**104.15.7 public final class ConfigurationPermission
 extends BasicPermission**

Indicates a bundle's authority to configure bundles. This permission has only a single action: `CONFIGURE`.

Since 1.2

104.15.7.1 public static final String CONFIGURE = "configure"

The action string `configure`.

104.15.7.2 public ConfigurationPermission(String name, String actions)

name Name must be “*”.

actions configure (canonical order).

- Create a new ConfigurationPermission.

104.15.7.3 public boolean equals(Object obj)

obj The object being compared for equality with this object.

- Determines the equality of two ConfigurationPermission objects.
Two ConfigurationPermission objects are equal.

Returns true if obj is equivalent to this ConfigurationPermission; false otherwise.

104.15.7.4 public String getActions()

- Returns the canonical string representation of the ConfigurationPermission actions.

Always returns present ConfigurationPermission actions in the following order: CONFIGURE

Returns Canonical string representation of the ConfigurationPermission actions.

104.15.7.5 public int hashCode()

- Returns the hash code value for this object.

Returns Hash code value for this object.

104.15.7.6 public boolean implies(Permission p)

p The target permission to check.

- Determines if a ConfigurationPermission object “implies” the specified permission.

Returns true if the specified permission is implied by this object; false otherwise.

104.15.7.7 public PermissionCollection newPermissionCollection()

- Returns a new PermissionCollection object suitable for storing ConfigurationPermissions.

Returns A new PermissionCollection object.

104.15.8 public interface ConfigurationPlugin

A service interface for processing configuration dictionary before the update.

A bundle registers a ConfigurationPlugin object in order to process configuration updates before they reach the Managed Service or Managed Service Factory. The Configuration Admin service will detect registrations of Configuration Plugin services and must call these services every time before it calls the ManagedService or ManagedServiceFactoryupdated method. The Configuration Plugin service thus has the opportunity to view and modify the properties before they are passed to the ManagedS ervice or Managed Service Factory.

Configuration Plugin (plugin) services have full read/write access to all configuration information. Therefore, bundles using this facility should be trusted. Access to this facility should be limited with `ServicePermission[ConfigurationPlugin,REGISTER]`. Implementations of a Configuration Plugin service should assure that they only act on appropriate configurations.

The `Integerservice.cmRanking` registration property may be specified. Not specifying this registration property, or setting it to something other than an Integer, is the same as setting it to the Integer zero. The `service.cmRanking` property determines the order in which plugins are invoked. Lower ranked plugins are called before higher ranked ones. In the event of more than one plugin having the same value of `service.cmRanking`, then the Configuration Admin service arbitrarily chooses the order in which they are called.

By convention, plugins with `service.cmRanking < 0` or `service.cmRanking > 1000` should not make modifications to the properties.

The Configuration Admin service has the right to hide properties from plugins, or to ignore some or all the changes that they make. This might be done for security reasons. Any such behavior is entirely implementation defined.

A plugin may optionally specify a `cm.target` registration property whose value is the PID of the Managed Service or Managed Service Factory whose configuration updates the plugin is intended to intercept. The plugin will then only be called with configuration updates that are targetted at the Managed Service or Managed Service Factory with the specified PID. Omitting the `cm.target` registration property means that the plugin is called for all configuration updates.

104.15.8.1 `public static final String CM_RANKING = "service.cmRanking"`

A service property to specify the order in which plugins are invoked. This property contains an Integer ranking of the plugin. Not specifying this registration property, or setting it to something other than an Integer, is the same as setting it to the Integer zero. This property determines the order in which plugins are invoked. Lower ranked plugins are called before higher ranked ones.

Since 1.2

104.15.8.2 `public static final String CM_TARGET = "cm.target"`

A service property to limit the Managed Service or Managed Service Factory configuration dictionaries a Configuration Plugin service receives. This property contains a `String[]` of PIDs. A Configuration Admin service must call a Configuration Plugin service only when this property is not set, or the target service's PID is listed in this property.

104.15.8.3 `public void modifyConfiguration(ServiceReference reference, Dictionary properties)`

reference reference to the Managed Service or Managed Service Factory

properties The configuration properties. This argument must not contain the “service.bundleLocation” property. The value of this property may be obtained from the Configuration.getBundLeLocation method.

- View and possibly modify the a set of configuration properties before they are sent to the Managed Service or the Managed Service Factory. The Configuration Plugin services are called in increasing order of their service.cmRanking property. If this property is undefined or is a non- Integer type, 0 is used.

This method should not modify the properties unless the service.cmRanking of this plugin is in the range $0 \leq \text{service.cmRanking} \leq 1000$.

If this method throws any Exception, the Configuration Admin service must catch it and should log it.

104.15.9 public interface ManagedService

A service that can receive configuration data from a Configuration Admin service.

A Managed Service is a service that needs configuration data. Such an object should be registered with the Framework registry with the service.pid property set to some unique identifier called a PID.

If the Configuration Admin service has a Configuration object corresponding to this PID, it will callback the updated() method of the ManagedService object, passing the properties of that Configuration object.

If it has no such Configuration object, then it calls back with a null properties argument. Registering a Managed Service will always result in a callback to the updated() method provided the Configuration Admin service is, or becomes active. This callback must always be done asynchronously.

Else, every time that either of the updated() methods is called on that Configuration object, the ManagedService.updated() method with the new properties is called. If the delete() method is called on that Configuration object, ManagedService.updated() is called with a null for the properties parameter. All these callbacks must be done asynchronously.

The following example shows the code of a serial port that will create a port depending on configuration information.

```
class SerialPort implements ManagedService {

    ServiceRegistration registration;
    Hashtable configuration;
    CommPortIdentifier id;

    synchronized void open(CommPortIdentifier id,
        BundleContext context) {
        this.id = id;
        registration = context.registerService(
            ManagedService.class.getName(),
            this,
            getDefaults())
    }
```

```

    );
}

Hashtable getDefaults() {
    Hashtable defaults = new Hashtable();
    defaults.put( "port", id.getName() );
    defaults.put( "product", "unknown" );
    defaults.put( "baud", "9600" );
    defaults.put( Constants.SERVICE_PID,
        "com.acme.serialport." + id.getName() );
    return defaults;
}

public synchronized void updated(
    Dictionary configuration ) {
    if ( configuration ==
null
    )
        registration.setProperties( getDefaults() );
    else {
        setSpeed( configuration.get("baud") );
        registration.setProperties( configuration );
    }
}
...
}

```

As a convention, it is recommended that when a Managed Service is updated, it should copy all the properties it does not recognize into the service registration properties. This will allow the Configuration Admin service to set properties on services which can then be used by other applications.

104.15.9.1 **public void updated(Dictionary properties) throws ConfigurationException**

properties A copy of the Configuration properties, or null. This argument must not contain the "service.bundleLocation" property. The value of this property may be obtained from the Configuration.getBundleLocation method.

- Update the configuration for a Managed Service.

When the implementation of updated(Dictionary) detects any kind of error in the configuration properties, it should create a new ConfigurationException which describes the problem. This can allow a management system to provide useful information to a human administrator.

If this method throws any other Exception, the Configuration Admin service must catch it and should log it.

The Configuration Admin service must call this method asynchronously which initiated the callback. This implies that implementors of Managed Service can be assured that the callback will not take place during registration when they execute the registration in a synchronized method.

Throws ConfigurationException – when the update fails

104.15.10**public interface ManagedServiceFactory**

Manage multiple service instances. Bundles registering this interface are giving the Configuration Admin service the ability to create and configure a number of instances of a service that the implementing bundle can provide. For example, a bundle implementing a DHCP server could be instantiated multiple times for different interfaces using a factory.

Each of these *service instances* is represented, in the persistent storage of the Configuration Admin service, by a factory Configuration object that has a PID. When such a Configuration is updated, the Configuration Admin service calls the ManagedServiceFactory updated method with the new properties. When updated is called with a new PID, the Managed Service Factory should create a new factory instance based on these configuration properties. When called with a PID that it has seen before, it should update that existing service instance with the new configuration information.

In general it is expected that the implementation of this interface will maintain a data structure that maps PIDs to the factory instances that it has created. The semantics of a factory instance are defined by the Managed Service Factory. However, if the factory instance is registered as a service object with the service registry, its PID should match the PID of the corresponding Configuration object (but it should **not** be registered as a Managed Service!).

An example that demonstrates the use of a factory. It will create serial ports under command of the Configuration Admin service.

```
class SerialPortFactory
    implements ManagedServiceFactory {
        ServiceRegistration registration;
        Hashtable ports;
        void start(BundleContext context) {
            Hashtable properties = new Hashtable();
            properties.put( Constants.SERVICE_PID,
                "com.acme.serialportfactory" );
            registration = context.registerService(
                ManagedServiceFactory.class.getName(),
                this,
                properties
            );
        }
        public void updated( String pid,
            Dictionary properties ) {
            String portName = (String) properties.get("port");
            SerialPortService port =
                (SerialPort) ports.get( pid );
            if ( port == null ) {
                port = new SerialPortService();
                ports.put( pid, port );
                port.open();
            }
            if ( port.getPortName().equals(portName) )
                return;
            port.setPortName( portName );
        }
    }
```

```

    }
    public void deleted( String pid ) {
        SerialPortService port =
            (SerialPort) ports.get( pid );
        port.close();
        ports.remove( pid );
    }
    ...
}

```

104.15.10.1 **public void deleted(String pid)**

pid the PID of the service to be removed

- Remove a factory instance. Remove the factory instance associated with the PID. If the instance was registered with the service registry, it should be unregistered.

If this method throws any Exception, the Configuration Admin service must catch it and should log it.

The Configuration Admin service must call this method asynchronously.

104.15.10.2 **public String getName()**

- Return a descriptive name of this factory.

Returns the name for the factory, which might be localized

104.15.10.3 **public void updated(String pid, Dictionary properties) throws ConfigurationException**

pid The PID for this configuration.

properties A copy of the configuration properties. This argument must not contain the service.bundleLocation" property. The value of this property may be obtained from the Configuration.getBundleLocation method.

- Create a new instance, or update the configuration of an existing instance. If the PID of the Configuration object is new for the Managed Service Factory, then create a new factory instance, using the configuration properties provided. Else, update the service instance with the provided properties.

If the factory instance is registered with the Framework, then the configuration properties should be copied to its registry properties. This is not mandatory and security sensitive properties should obviously not be copied.

If this method throws any Exception, the Configuration Admin service must catch it and should log it.

When the implementation of updated detects any kind of error in the configuration properties, it should create a new ConfigurationException[p.99] which describes the problem.

The Configuration Admin service must call this method asynchronously. This implies that implementors of the ManagedServiceFactory class can be assured that the callback will not take place during registration when they execute the registration in a synchronized method.

Throws ConfigurationException – when the configuration properties are invalid.

104.16 References

- [16] *DMTF Common Information Model*
<http://www.dmtf.org>
- [17] *Simple Network Management Protocol*
RFCs <http://directory.google.com/Top/Computers/Internet/Protocols/SNMP/RFCs>
- [18] *XSchema*
<http://www.w3.org/TR/xmlschema-0/>
- [19] *Interface Definition Language*
<http://www.omg.org>
- [20] *Lightweight Directory Access Protocol*
<http://directory.google.com/Top/Computers/Software/Internet/Servers/Directory/LDAP>
- [21] *Understanding and Deploying LDAP Directory services*
Timothy Howes et. al. ISBN 1-57870-070-1, MacMillan Technical publishing.

106 Preferences Service Specification

Version 1.1

106.1 Introduction

Many bundles need to save some data persistently--in other words, the data is required to survive the stopping and restarting of the bundle, Framework and OSGi Service Platform. In some cases, the data is specific to a particular user. For example, imagine a bundle that implements some kind of game. User specific persistent data could include things like the user's preferred difficulty level for playing the game. Some data is not specific to a user, which we call *system* data. An example would be a table of high scores for the game.

Bundles which need to persist data in an OSGi environment can use the file system via `org.osgi.framework.BundleContext.getDataFile`. A file system, however, can store only bytes and characters, and provides no direct support for named values and different data types.

A popular class used to address this problem for Java applications is the `java.util.Properties` class. This class allows data to be stored as key/value pairs, called *properties*. For example, a property could have a name `com.acme.fudd` and a value of `elmer`. The `Properties` class has rudimentary support for storage and retrieving with its `load` and `store` methods. The `Properties` class, however, has the following limitations:

- Does not support a naming hierarchy.
- Only supports String property values.
- Does not allow its content to be easily stored in a back-end system.
- Has no user name-space management.

Since the `Properties` class was introduced in Java 1.0, efforts have been undertaken to replace it with a more sophisticated mechanism. One of these efforts is this Preferences Service specification.

106.1.1 Essentials

The focus of this specification is simplicity, not reliable access to stored data. This specification does *not* define a general database service with transactions and atomicity guarantees. Instead, it is optimized to deliver the stored information when needed, but it will return defaults, instead of throwing an exception, when the back-end store is not available. This approach may reduce the reliability of the data, but it makes the service easier to use, and allows for a variety of compact and efficient implementations.

This API is made easier to use by the fact that many bundles can be written to ignore any problems that the Preferences Service may have in accessing the back-end store, if there is one. These bundles will mostly or exclusively use the methods of the Preferences interface which are not declared to throw a `BackingStoreException`.

This service only supports the storage of scalar values and byte arrays. It is not intended for storing large data objects like documents or images. No standard limits are placed on the size of data objects which can be stored, but implementations are expected to be optimized for the handling of small objects.

A hierarchical naming model is supported, in contrast to the flat model of the `Properties` class. A hierarchical model maps naturally to many computing problems. For example, maintaining information about the positions of adjustable seats in a car requires information for each seat. In a hierarchy, this information can be modeled as a node per seat.

A potential benefit of the Preferences Service is that it allows user specific preferences data to be kept in a well defined place, so that a user management system could locate it. This benefit could be useful for such operations as cleaning up files when a user is removed from the system, or to allow a user's preferences to be cloned for a new user.

The Preferences Service does *not* provide a mechanism to allow one bundle to access the preferences data of another. If a bundle wishes to allow another bundle to access its preferences data, it can pass a [Preferences](#) or [PreferencesService](#) object to that bundle.

The Preferences Service is not intended to provide configuration management functionality. For information regarding Configuration Management, refer to the *Configuration Admin Service Specification* on page 63.

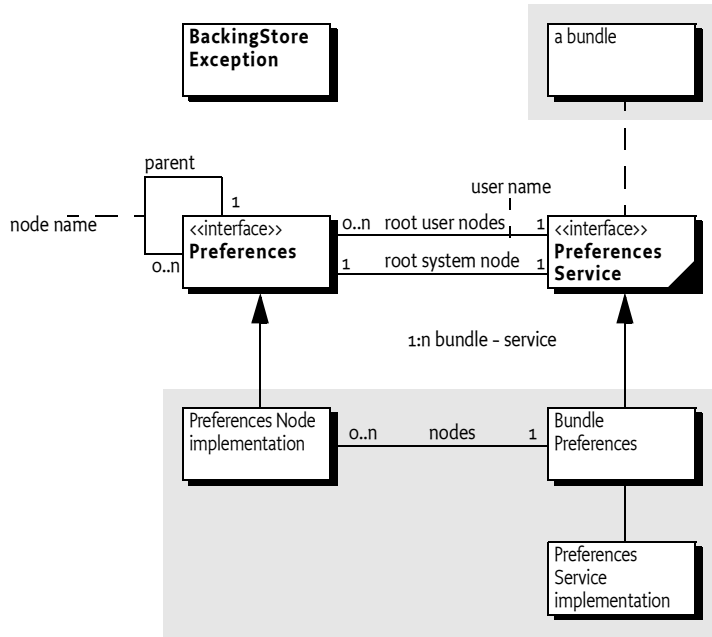
106.1.2 Entities

The `PreferencesService` is a relatively simple service. It provides access to the different roots of Preferences trees. A single system root node and any number of user root nodes are supported. Each *node* of such a tree is an object that implements the Preferences interface.

This Preferences interface provides methods for traversing the tree, as well as methods for accessing the properties of the node. This interface also contains the methods to flush data into persistent storage, and to synchronize the in-memory data cache with the persistent storage.

All nodes except root nodes have a parent. Nodes can have multiple children.

Figure 21 Preferences Class Diagram



106.1.3 Operation

The purpose of the Preferences Service specification is to allow bundles to store and retrieve properties stored in a tree of nodes, where each node implements the Preferences interface. The PreferencesService interface allows a bundle to create or obtain a Preferences tree for system properties, as well as a Preferences tree for each user of the bundle.

This specification allows for implementations where the data is stored locally on the service platform or remotely on a back-end system.

106.2 Preferences Interface

Preferences is an interface that defines the methods to manipulate a node and the tree to which it belongs. A Preferences object contains:

- A set of properties in the form of key/value pairs.
- A parent node.
- A number of child nodes.

106.2.1 Hierarchies

A valid Preferences object always belongs to a *tree*. A tree is identified by its root node. In such a tree, a Preferences object always has a single parent, except for a root node which has a null parent.

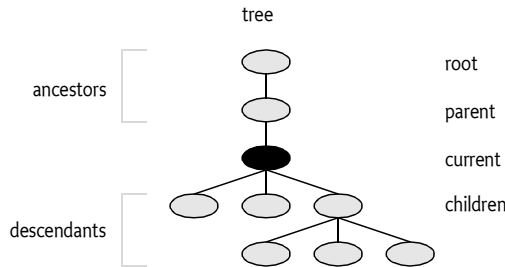
The root node of a tree can be found by recursively calling the `parent()` method of a node until null is returned. The nodes that are traversed this way are called the *ancestors* of a node.

Each Preferences object has a private name-space for child nodes. Each child node has a name that must be unique among its siblings. Child nodes are created by getting a child node with the `node(String)` method. The String argument of this call contains a path name. Path names are explained in the next section.

Child nodes can have child nodes recursively. These objects are called the *descendants* of a node.

Descendants are automatically created when they are obtained from a Preferences object, including any intermediate nodes that are necessary for the given path. If this automatic creation is not desired, the `nodeExists(String)` method can be used to determine if a node already exists.

Figure 22 Categorization of nodes in a tree



106.2.2 Naming

Each node has a name relative to its parent. A name may consist of Unicode characters except for the forward slash ("/"). There are no special names, like ".." or ".".

Empty names are reserved for root nodes. Node names that are directly created by a bundle must *always* contain at least one character.

Preferences node names and property keys are *case sensitive*: for example, "org.osgi" and "oRg.oSgI" are two distinct names.

The Preferences Service supports different roots, so there is no absolute root for the Preferences Service. This concept is similar to the Windows Registry that also supports a number of roots.

A path consists of one or more node names, separated by a slash ("/"). Paths beginning with a "/" are called *absolute paths* while other paths are called *relative paths*. Paths cannot end with a "/" except for the special case of the root node which has absolute path "/".

Path names are always associated with a specific node; this node is called the current node in the following descriptions. Paths identify nodes as follows.

- *Absolute path* – The first "/" is removed from the path, and the remainder of the path is interpreted as a relative path from the tree's root node.
- *Relative path* –
 - If the path is the empty string, it identifies the current node.
 - If the path is a name (does not contain a "/"), then it identifies the child node with that name.

- Otherwise, the first name from the path identifies a child of the current node. The name and slash are then removed from the path, and the remainder of the path is interpreted as a relative path from the child node.

106.2.3 Tree Traversal Methods

A tree can be traversed and modified with the following methods:

- `childrenNames()` – Returns the names of the child nodes.
- `parent()` – Returns the parent node.
- `removeNode()` – Removes this node and all its descendants.
- `node(String)` – Returns a Preferences object, which is created if it does not already exist. The parameter is an absolute or relative path.
- `nodeExists(String)` – Returns true if the Preferences object identified by the path parameter exists.

106.2.4 Properties

Each Preferences node has a set of key/value pairs called properties. These properties consist of:

- *Key* – A key is a String object and *case sensitive*.
- The name-space of these keys is separate from that of the child nodes. A Preferences node could have both a child node named fudd and a property named fudd.
- *Value* – A value can always be stored and retrieved as a String object. Therefore, it must be possible to encode/decode all values into/from String objects (though it is not required to store them as such, an implementation is free to store and retrieve the value in any possible way as long as the String semantics are maintained). A number of methods are available to store and retrieve values as primitive types. These methods are provided both for the convenience of the user of the Preferences interface, and to allow an implementation the option of storing the values in a more compact form.

All the keys that are defined in a Preferences object can be obtained with the `keys()` method. The `clear()` method can be used to clear all properties from a Preferences object. A single property can be removed with the `remove(String)` method.

106.2.5 Storing and Retrieving Properties

The Preferences interface has a number of methods for storing and retrieving property values based on their key. All the `put*` methods take as parameters a key and a value. All the `get*` methods take as parameters a key and a default value.

- `put(String,String), get(String,String)`
- `putBoolean(String,boolean), getBoolean(String,boolean)`
- `putInt(String,int), getInt(String,int)`
- `putLong(String,long), getLong(String,long)`
- `putFloat(String,float), getFloat(String,float)`
- `putDouble(String,double), getDouble(String,double)`
- `putByteArray(String,byte[]), getByteArray(String,byte[])`

The methods act as if all the values are stored as String objects, even though implementations may use different representations for the different types. For example, a property can be written as a String object and read back as a float, providing that the string can be parsed as a valid Java float object. In the event of a parsing error, the `get*` methods do not raise exceptions, but instead return their default parameters.

106.2.6 Defaults

All `get*` methods take a default value as a parameter. The reasons for having such a default are:

- When a property for a Preferences object has not been set, the default is returned instead. In most cases, the bundle developer does not have to distinguish whether or not a property exists.
- A *best effort* strategy has been a specific design choice for this specification. The bundle developer should not have to react when the back-end store is not available. In those cases, the default value is returned without further notice.

Bundle developers who want to assure that the back-end store is available should call the `flush` or `sync` method. Either of these methods will throw a `BackingStoreException` if the back-end store is not available.

106.3 Concurrency

This specification specifically allows an implementation to modify Preferences objects in a back-end store. If the back-end store is shared by multiple processes, concurrent updates may cause differences between the back-end store and the in-memory Preferences objects.

Bundle developers can partly control this concurrency with the `flush()` and `sync()` method. Both methods operate on a Preferences object.

The `flush` method performs the following actions:

- Stores (makes persistent) any ancestors (including the current node) that do not exist in the persistent store.
- Stores any properties which have been modified in this node since the last time it was flushed.
- Removes from the persistent store any child nodes that were removed from this object since the last time it was flushed.
- Flushes all existing child nodes.

The `sync` method will first flush, and then ensure that any changes that have been made to the current node and its descendents in the back-end store (by some other process) take effect. For example, it could fetch all the descendants into a local cache, or it could clear all the descendants from the cache so that they will be read from the back-end store as required.

If either method fails, a `BackingStoreException` is thrown.

The flush or sync methods provide no atomicity guarantee. When updates to the same back-end store are done concurrently by two different processes, the result may be that changes made by different processes are intermingled. To avoid this problem, implementations may simply provide a dedicated section (or name-space) in the back-end store for each OSGi environment, so that clashes do not arise, in which case there is no reason for bundle programmers to ever call sync.

In cases where sync is used, the bundle programmer needs to take into account that changes from different processes may become intermingled, and the level of granularity that can be assumed is the individual property level. Hence, for example, if two properties need to be kept in lockstep, so that one should not be changed without a corresponding change to the other, consider combining them into a single property, which would then need to be parsed into its two constituent parts.

106.4 PreferencesService Interface

The PreferencesService is obtained from the Framework's service registry in the normal way. Its purpose is to provide access to Preferences root nodes.

A Preferences Service maintains a system root and a number of user roots. User roots are automatically created, if necessary, when they are requested. Roots are maintained on a per bundle basis. For example, a user root called elmer in one bundle is distinct from a user root with the same name in another bundle. Also, each bundle has its own system root. Implementations should use a ServiceFactory service object to create a separate PreferencesService object for each bundle.

The precise description of *user* and *system* will vary from one bundle to another. The Preference Service only provides a mechanism, the bundle may use this mechanism in any desired way.

The PreferencesService interface has the following methods to access the system root and user roots:

- `getSystemPreferences()` – Return a Preferences object that is the root of the system preferences tree.
- `getUserPreferences(String)` – Return a Preferences object associated with the user name that is given as argument. If the user does not exist, a new root is created atomically.
- `getUsers()` – Return an array of the names of all the users for whom a Preferences tree exists.

106.5 Cleanup

The Preferences Service must listen for bundle uninstall events, and remove all the preferences data for the bundle that is being uninstalled.

It also must handle the possibility of a bundle getting uninstalled while the Preferences Service is stopped. Therefore, it must check on startup whether preferences data exists for any bundle which is not currently installed. If it does, that data must be removed.

106.6 Changes

- Root nodes can be removed with `Preferences.removeNode`. This allows a user root node to be removed when a user has been removed.
- `BackingStoreException` has been updated to support the Java 1.4 nested exception methods.

106.7 org.osgi.service.prefs

The OSGi Preferences Service Package, Specification Version 1.1.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.service.prefs; version=1.1

106.7.1 Summary

- `BackingStoreException` - Thrown to indicate that a preferences operation could not complete because of a failure in the backing store, or a failure to contact the backing store. [p.116]
- `Preferences` - A node in a hierarchical collection of preference data. [p.117]
- `PreferencesService` - The Preferences Service. [p.127]

106.7.2 **public class BackingStoreException** **extends Exception**

Thrown to indicate that a preferences operation could not complete because of a failure in the backing store, or a failure to contact the backing store.

106.7.2.1 **public BackingStoreException(String s)**

s The detail message.

- Constructs a `BackingStoreException` with the specified detail message.

106.7.2.2 **public BackingStoreException(String s, Throwable cause)**

s The detail message.

cause The cause of the exception. May be null.

- Constructs a `BackingStoreException` with the specified detail message.

Since 1.1

106.7.2.3 **public Throwable getCause()**

- Returns the cause of this exception or null if no cause was specified when this exception was created.

Returns The cause of this exception or null if no cause was specified.

Since 1.1

106.7.2.4 **public Throwable initCause(Throwable cause)**

cause Cause of the exception.

- The cause of this exception can only be set when constructed.

Returns This object.

Throws `IllegalStateException` – This method will always throw an `IllegalStateException` since the cause of this exception can only be set when constructed.

Since 1.1

106.7.3 public interface Preferences

A node in a hierarchical collection of preference data.

This interface allows applications to store and retrieve user and system preference data. This data is stored persistently in an implementation-dependent backing store. Typical implementations include flat files, OS-specific registries, directory servers and SQL databases.

For each bundle, there is a separate tree of nodes for each user, and one for system preferences. The precise description of “user” and “system” will vary from one bundle to another. Typical information stored in the user preference tree might include font choice, and color choice for a bundle which interacts with the user via a servlet. Typical information stored in the system preference tree might include installation data, or things like high score information for a game program.

Nodes in a preference tree are named in a similar fashion to directories in a hierarchical file system. Every node in a preference tree has a *node name* (which is not necessarily unique), a unique *absolute path name*, and a path name *relative* to each ancestor including itself.

The root node has a node name of the empty String object (“”). Every other node has an arbitrary node name, specified at the time it is created. The only restrictions on this name are that it cannot be the empty string, and it cannot contain the slash character (“/”).

The root node has an absolute path name of “/”. Children of the root node have absolute path names of “/” + <node name>. All other nodes have absolute path names of <parent’s absolute path name> + “/” + <node name>. Note that all absolute path names begin with the slash character.

A node *n*’s path name relative to its ancestor *a* is simply the string that must be appended to *a*’s absolute path name in order to form *n*’s absolute path name, with the initial slash character (if present) removed. Note that:

- No relative path names begin with the slash character.
- Every node’s path name relative to itself is the empty string.
- Every node’s path name relative to its parent is its node name (except for the root node, which does not have a parent).
- Every node’s path name relative to the root is its absolute path name with the initial slash character removed.

Note finally that:

- No path name contains multiple consecutive slash characters.
- No path name with the exception of the root’s absolute path name end in the slash character.
- Any string that conforms to these two rules is a valid path name.

Each Preference node has zero or more properties associated with it, where a property consists of a name and a value. The bundle writer is free to choose any appropriate names for properties. Their values can be of type String, long, int, boolean, byte[], float, or double but they can always be accessed as if they were String objects.

All node name and property name comparisons are case-sensitive.

All of the methods that modify preference data are permitted to operate asynchronously; they may return immediately, and changes will eventually propagate to the persistent backing store, with an implementation-dependent delay. The flush method may be used to synchronously force updates to the backing store.

Implementations must automatically attempt to flush to the backing store any pending updates for a bundle's preferences when the bundle is stopped or otherwise ungets the Preferences Service.

The methods in this class may be invoked concurrently by multiple threads in a single Java Virtual Machine (JVM) without the need for external synchronization, and the results will be equivalent to some serial execution. If this class is used concurrently *by multiple JVMs* that store their preference data in the same backing store, the data store will not be corrupted, but no other guarantees are made concerning the consistency of the preference data.

106.7.3.1 **public String absolutePath()**

- Returns this node's absolute path name. Note that:
 - Root node - The path name of the root node is "/".
 - Slash at end - Path names other than that of the root node may not end in slash ("/").
 - Unusual names - "." and ".." have *no* special significance in path names.
 - Illegal names - The only illegal path names are those that contain multiple consecutive slashes, or that end in slash and are not the root.

Returns this node's absolute path name.

106.7.3.2 **public String[] childrenNames() throws BackingStoreException**

- Returns the names of the children of this node. (The returned array will be of size zero if this node has no children and not null!)

Returns the names of the children of this node.

Throws BackingStoreException – if this operation cannot be completed due to a failure in the backing store, or inability to communicate with it.

IllegalStateException – if this node (or an ancestor) has been removed with the removeNode()[p.126] method.

106.7.3.3 **public void clear() throws BackingStoreException**

- Removes all of the properties (key-value associations) in this node. This call has no effect on any descendants of this node.

Throws BackingStoreException – if this operation cannot be completed due to a failure in the backing store, or inability to communicate with it.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `remove(String)`[p.126]

106.7.3.4 `public void flush() throws BackingStoreException`

- Forces any changes in the contents of this node and its descendants to the persistent store.

Once this method returns successfully, it is safe to assume that all changes made in the subtree rooted at this node prior to the method invocation have become permanent.

Implementations are free to flush changes into the persistent store at any time. They do not need to wait for this method to be called.

When a flush occurs on a newly created node, it is made persistent, as are any ancestors (and descendants) that have yet to be made persistent. Note however that any properties value changes in ancestors are *not* guaranteed to be made persistent.

Throws `BackingStoreException` – if this operation cannot be completed due to a failure in the backing store, or inability to communicate with it.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `sync()`[p.126]

106.7.3.5 `public String get(String key, String def)`

key key whose associated value is to be returned.

def the value to be returned in the event that this node has no value associated with key or the backing store is inaccessible.

- Returns the value associated with the specified key in this node. Returns the specified default if there is no value associated with the key, or the backing store is inaccessible.

Returns the value associated with key, or def if no value is associated with key.

Throws `IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

`NullPointerException` – if key is null. (A null default is permitted.)

106.7.3.6 `public boolean getBoolean(String key, boolean def)`

key key whose associated value is to be returned as a boolean.

def the value to be returned in the event that this node has no value associated with key or the associated value cannot be interpreted as a boolean or the backing store is inaccessible.

- Returns the boolean value represented by the String object associated with the specified key in this node. Valid strings are “true”, which represents true, and “false”, which represents false. Case is ignored, so, for example, “TRUE” and “False” are also valid. This method is intended for use in conjunction with the `putBoolean`[p.124] method.

Returns the specified default if there is no value associated with the key, the backing store is inaccessible, or if the associated value is something other than “true” or “false”, ignoring case.

Returns the boolean value represented by the String object associated with key in this node, or null if the associated value does not exist or cannot be interpreted as a boolean.

Throws NullPointerException – if key is null.

IllegalStateException – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `get(String, String)`[p.119], `putBoolean(String, boolean)`[p.124]

106.7.3.7 **public byte[] getByteArray(String key, byte[] def)**

key key whose associated value is to be returned as a byte[] object.

def the value to be returned in the event that this node has no value associated with key or the associated value cannot be interpreted as a byte[] type, or the backing store is inaccessible.

- Returns the byte[] value represented by the String object associated with the specified key in this node. Valid String objects are *Base64* encoded binary data, as defined in RFC 2045 (<http://www.ietf.org/rfc/rfc2045.txt>), Section 6.8, with one minor change: the string must consist solely of characters from the *Base64 Alphabet*; no newline characters or extraneous characters are permitted. This method is intended for use in conjunction with the `putByteArray`[p.124] method.

Returns the specified default if there is no value associated with the key, the backing store is inaccessible, or if the associated value is not a valid Base64 encoded byte array (as defined above).

Returns the byte[] value represented by the String object associated with key in this node, or def if the associated value does not exist or cannot be interpreted as a byte[].

Throws NullPointerException – if key is null. (A null value for def is permitted.)

IllegalStateException – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `get(String, String)`[p.119], `putByteArray(String, byte[])`[p.124]

106.7.3.8 **public double getDouble(String key, double def)**

key key whose associated value is to be returned as a double value.

def the value to be returned in the event that this node has no value associated with key or the associated value cannot be interpreted as a double type or the backing store is inaccessible.

- Returns the double value represented by the String object associated with the specified key in this node. The String object is converted to a double value as by `Double.parseDouble(String)`. Returns the specified default if there is no value associated with the key, the backing store is inaccessible, or if `Double.parseDouble(String)` would throw a `NumberFormatException` if the associated value were passed. This method is intended for use in conjunction with the `putDouble`[p.124] method.

Returns the double value represented by the String object associated with key in this node, or def if the associated value does not exist or cannot be interpreted as a double type.

Throws `IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

`NullPointerException` – if key is null.

See Also `putDouble(String, double)`[p.124], `get(String, String)`[p.119]

106.7.3.9 `public float getFloat(String key, float def)`

key key whose associated value is to be returned as a float value.

def the value to be returned in the event that this node has no value associated with key or the associated value cannot be interpreted as a float type or the backing store is inaccessible.

- Returns the float value represented by the String object associated with the specified key in this node. The String object is converted to a float value as by `Float.parseFloat(String)`. Returns the specified default if there is no value associated with the key, the backing store is inaccessible, or if `Float.parseFloat(String)` would throw a `NumberFormatException` if the associated value were passed. This method is intended for use in conjunction with the `putFloat`[p.125] method.

Returns the float value represented by the string associated with key in this node, or def if the associated value does not exist or cannot be interpreted as a float type.

Throws `IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

`NullPointerException` – if key is null.

See Also `putFloat(String, float)`[p.125], `get(String, String)`[p.119]

106.7.3.10 `public int getInt(String key, int def)`

key key whose associated value is to be returned as an int.

def the value to be returned in the event that this node has no value associated with key or the associated value cannot be interpreted as an int or the backing store is inaccessible.

- Returns the int value represented by the String object associated with the specified key in this node. The String object is converted to an int as by `Integer.parseInt(String)`. Returns the specified default if there is no value associated with the key, the backing store is inaccessible, or if `Integer.parseInt(String)` would throw a `NumberFormatException` if the associated value were passed. This method is intended for use in conjunction with the `putInt`[p.125] method.

Returns the int value represented by the String object associated with key in this node, or def if the associated value does not exist or cannot be interpreted as an int type.

Throws `NullPointerException` – if key is null.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `putInt(String,int)[p.125]`, `get(String,String)[p.119]`

106.7.3.11 **public long getLong(String key, long def)**

key key whose associated value is to be returned as a long value.

def the value to be returned in the event that this node has no value associated with key or the associated value cannot be interpreted as a long type or the backing store is inaccessible.

- Returns the long value represented by the String object associated with the specified key in this node. The String object is converted to a long as by `Long.parseLong(String)`. Returns the specified default if there is no value associated with the key, the backing store is inaccessible, or if `Long.parseLong(String)` would throw a `NumberFormatException` if the associated value were passed. This method is intended for use in conjunction with the `putLong[p.126]` method.

Returns the long value represented by the String object associated with key in this node, or def if the associated value does not exist or cannot be interpreted as a long type.

Throws `NullPointerException` – if key is null.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()[p.126]` method.

See Also `putLong(String,long)[p.126]`, `get(String,String)[p.119]`

106.7.3.12 **public String[] keys() throws BackingStoreException**

- Returns all of the keys that have an associated value in this node. (The returned array will be of size zero if this node has no preferences and not null!)

Returns an array of the keys that have an associated value in this node.

Throws `BackingStoreException` – if this operation cannot be completed due to a failure in the backing store, or inability to communicate with it.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()[p.126]` method.

106.7.3.13 **public String name()**

- Returns this node's name, relative to its parent.

Returns this node's name, relative to its parent.

106.7.3.14 **public Preferences node(String pathName)**

pathName the path name of the Preferences object to return.

- Returns a named Preferences object (node), creating it and any of its ancestors if they do not already exist. Accepts a relative or absolute pathname. Absolute pathnames (which begin with '/') are interpreted relative to the root of this node. Relative pathnames (which begin with any character other than '/') are interpreted relative to this node itself. The empty string ("") is a valid relative pathname, referring to this node itself.

If the returned node did not exist prior to this call, this node and any ancestors that were created by this call are not guaranteed to become persistent until the flush method is called on the returned node (or one of its descendants).

Returns the specified Preferences object.

Throws `IllegalArgumentException` – if the path name is invalid.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

`NullPointerException` – if path name is null.

See Also `flush()` [p.119]

106.7.3.15 `public boolean nodeExists(String pathName) throws BackingStoreException`

pathName the path name of the node whose existence is to be checked.

- Returns true if the named node exists. Accepts a relative or absolute path-name. Absolute pathnames (which begin with '/') are interpreted relative to the root of this node. Relative pathnames (which begin with any character other than '/') are interpreted relative to this node itself. The pathname "" is valid, and refers to this node itself.

If this node (or an ancestor) has already been removed with the `removeNode()`[p.126] method, it is legal to invoke this method, but only with the pathname ""; the invocation will return false. Thus, the idiom `p.nodeExists("")` may be used to test whether p has been removed.

Returns true if the specified node exists.

Throws `BackingStoreException` – if this operation cannot be completed due to a failure in the backing store, or inability to communicate with it.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method and pathname is not the empty string ("").

`IllegalArgumentException` – if the path name is invalid (i.e., it contains multiple consecutive slash characters, or ends with a slash character and is more than one character long).

106.7.3.16 `public Preferences parent()`

- Returns the parent of this node, or null if this is the root.

Returns the parent of this node.

Throws `IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

106.7.3.17 `public void put(String key, String value)`

key key with which the specified value is to be associated.

value value to be associated with the specified key.

- Associates the specified value with the specified key in this node.

Throws `NullPointerException` – if key or value is null.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

106.7.3.18 `public void putBoolean(String key, boolean value)`

key key with which the string form of value is to be associated.

value value whose string form is to be associated with key.

- Associates a `String` object representing the specified boolean value with the specified key in this node. The associated string is “true” if the value is true, and “false” if it is false. This method is intended for use in conjunction with the `getBoolean`[p.119] method.

Implementor’s note: it is *not* necessary that the value be represented by a string in the backing store. If the backing store supports boolean values, it is not unreasonable to use them. This implementation detail is not visible through the Preferences API, which allows the value to be read as a boolean (with `getBoolean`) or a `String` (with `get`) type.

Throws `NullPointerException` – if key is null.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `getBoolean(String, boolean)` [p.119], `get(String, String)` [p.119]

106.7.3.19 `public void putByteArray(String key, byte[] value)`

key key with which the string form of value is to be associated.

value value whose string form is to be associated with key.

- Associates a `String` object representing the specified `byte[]` with the specified key in this node. The associated `String` object is the *Base64* encoding of the `byte[]`, as defined in RFC 2045 (<http://www.ietf.org/rfc/rfc2045.txt>), Section 6.8, with one minor change: the string will consist solely of characters from the *Base64 Alphabet*; it will not contain any newline characters. This method is intended for use in conjunction with the `getByteArray`[p.120] method.

Implementor’s note: it is *not* necessary that the value be represented by a `String` type in the backing store. If the backing store supports `byte[]` values, it is not unreasonable to use them. This implementation detail is not visible through the Preferences API, which allows the value to be read as an `byte[]` object (with `getByteArray`) or a `String` object (with `get`).

Throws `NullPointerException` – if key or value is null.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `getByteArray(String, byte[])` [p.120], `get(String, String)` [p.119]

106.7.3.20 `public void putDouble(String key, double value)`

key key with which the string form of value is to be associated.

value value whose string form is to be associated with key.

- Associates a String object representing the specified double value with the specified key in this node. The associated String object is the one that would be returned if the double value were passed to Double.toString(double). This method is intended for use in conjunction with the getDouble[p.120] method

Implementor's note: it is *not* necessary that the value be represented by a string in the backing store. If the backing store supports double values, it is not unreasonable to use them. This implementation detail is not visible through the Preferences API, which allows the value to be read as a double (with getDouble) or a String (with get) type.

Throws NullPointerException – if key is null.

IllegalStateException – if this node (or an ancestor) has been removed with the removeNode()[p.126] method.

See Also getDouble(String, double)[p.120]

106.7.3.21 **public void putFloat(String key, float value)**

key key with which the string form of value is to be associated.

value value whose string form is to be associated with key.

- Associates a String object representing the specified float value with the specified key in this node. The associated String object is the one that would be returned if the float value were passed to Float.toString(float). This method is intended for use in conjunction with the getFloat[p.121] method.

Implementor's note: it is *not* necessary that the value be represented by a string in the backing store. If the backing store supports float values, it is not unreasonable to use them. This implementation detail is not visible through the Preferences API, which allows the value to be read as a float (with getFloat) or a String (with get) type.

Throws NullPointerException – if key is null.

IllegalStateException – if this node (or an ancestor) has been removed with the removeNode()[p.126] method.

See Also getFloat(String, float)[p.121]

106.7.3.22 **public void putInt(String key, int value)**

key key with which the string form of value is to be associated.

value value whose string form is to be associated with key.

- Associates a String object representing the specified int value with the specified key in this node. The associated string is the one that would be returned if the int value were passed to Integer.toString(int). This method is intended for use in conjunction with getInt[p.121] method.

Implementor's note: it is *not* necessary that the property value be represented by a String object in the backing store. If the backing store supports integer values, it is not unreasonable to use them. This implementation detail is not visible through the Preferences API, which allows the value to be read as an int (with getInt or a String (with get) type.

Throws NullPointerException – if key is null.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `getInt(String, int)`[p.121]

106.7.3.23 **public void putLong(String key, long value)**

key key with which the string form of value is to be associated.

value value whose string form is to be associated with key.

- Associates a `String` object representing the specified long value with the specified key in this node. The associated `String` object is the one that would be returned if the long value were passed to `Long.toString(long)`. This method is intended for use in conjunction with the `getLong`[p.122] method.

Implementor's note: it is *not* necessary that the value be represented by a `String` type in the backing store. If the backing store supports long values, it is not unreasonable to use them. This implementation detail is not visible through the Preferences API, which allows the value to be read as a long (with `getLong` or a `String` (with `get`) type.

Throws `NullPointerException` – if key is null.

`IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `getLong(String, long)`[p.122]

106.7.3.24 **public void remove(String key)**

key key whose mapping is to be removed from this node.

- Removes the value associated with the specified key in this node, if any.

Throws `IllegalStateException` – if this node (or an ancestor) has been removed with the `removeNode()`[p.126] method.

See Also `get(String, String)`[p.119]

106.7.3.25 **public void removeNode() throws BackingStoreException**

- Removes this node and all of its descendants, invalidating any properties contained in the removed nodes. Once a node has been removed, attempting any method other than `name()`, `absolutePath()` or `nodeExists("")` on the corresponding Preferences instance will fail with an `IllegalStateException`. (The methods defined on `Object` can still be invoked on a node after it has been removed; they will not throw `IllegalStateException`.)

The removal is not guaranteed to be persistent until the `flush` method is called on the parent of this node.

Throws `IllegalStateException` – if this node (or an ancestor) has already been removed with the `removeNode()`[p.126] method.

`BackingStoreException` – if this operation cannot be completed due to a failure in the backing store, or inability to communicate with it.

See Also `flush()`[p.119]

106.7.3.26 **public void sync() throws BackingStoreException**

- Ensures that future reads from this node and its descendants reflect any changes that were committed to the persistent store (from any VM) prior to the sync invocation. As a side-effect, forces any changes in the contents of this node and its descendants to the persistent store, as if the flush method had been invoked on this node.

Throws BackingStoreException – if this operation cannot be completed due to a failure in the backing store, or inability to communicate with it.

IllegalStateException – if this node (or an ancestor) has been removed with the removeNode()[p.126] method.

See Also flush()[p.119]

106.7.4 **public interface PreferencesService**

The Preferences Service.

Each bundle using this service has its own set of preference trees: one for system preferences, and one for each user.

A PreferencesService object is specific to the bundle which obtained it from the service registry. If a bundle wishes to allow another bundle to access its preferences, it should pass its PreferencesService object to that bundle.

106.7.4.1 **public Preferences getSystemPreferences()**

- Returns the root system node for the calling bundle.

Returns The root system node for the calling bundle.

106.7.4.2 **public Preferences getUserPreferences(String name)**

name The user for which to return the preference root node.

- Returns the root node for the specified user and the calling bundle.

Returns The root node for the specified user and the calling bundle.

106.7.4.3 **public String[] getUsers()**

- Returns the names of users for which node trees exist.

Returns The names of users for which node trees exist.

106.8 References

- [22] *JSR 10 Preferences API*
<http://www.jcp.org/jsr/detail/10.jsp>
- [23] *RFC 2045 Base 64 encoding*
<http://www.ietf.org/rfc/rfc2045.txt>

105 Metatype Service Specification

Version 1.1

105.1 Introduction

The Metatype specification defines interfaces that allow bundle developers to describe attribute types in a computer readable form using so-called *meta-data*.

The purpose of this specification is to allow services to specify the type information of data that they can use as arguments. The data is based on *attributes*, which are key/value pairs like properties.

A designer in a type-safe language like Java is often confronted with the choice of using the language constructs to exchange data or using a technique based on attributes/properties that are based on key/value pairs. Attributes provide an escape from the rigid type-safety requirements of modern programming languages.

Type-safety works very well for software development environments in which multiple programmers work together on large applications or systems, but often lacks the flexibility needed to receive structured data from the outside world.

The attribute paradigm has several characteristics that make this approach suitable when data needs to be communicated between different entities which “speak” different languages. Attributes are uncomplicated, resilient to change, and allow the receiver to dynamically adapt to different types of data.

As an example, the OSGi Service Platform Specifications define several attribute types which are used in a Framework implementation, but which are also used and referenced by other OSGi specifications such as the *Configuration Admin Service Specification* on page 63. A Configuration Admin service implementation deploys attributes (key/value pairs) as configuration properties.

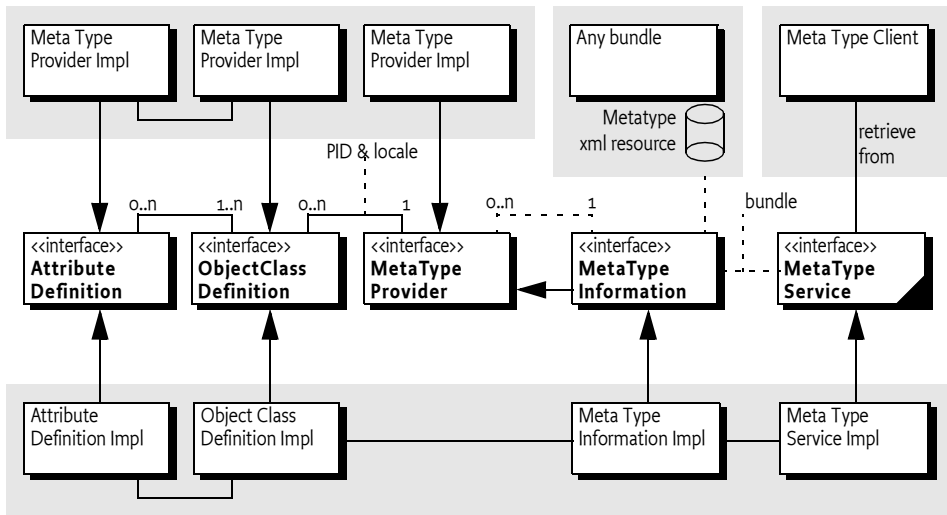
The Meta Type Service provides a unified access point to the Meta Type information that is associated with bundles. This Meta Type information can be defined by an XML resource in a bundle (OSGI-INF/metatype directories must be scanned for any XML resources), or it can be obtained from Managed Service or Managed Service Factory services that are implemented by a bundle.

105.1.1**Essentials**

- *Conceptual model* – The specification must have a conceptual model for how classes and attributes are organized.
- *Standards* – The specification should be aligned with appropriate standards, and explained in situations where the specification is not aligned with, or cannot be mapped to, standards.
- *Remote Management* – Remote management should be taken into account.
- *Size* – Minimal overhead in size for a bundle using this specification is required.
- *Localization* – It must be possible to use this specification with different languages at the same time. This ability allows servlets to serve information in the language selected in the browser.
- *Type information* – The definition of an attribution should contain the name (if it is required), the cardinality, a label, a description, labels for enumerated values, and the Java class that should be used for the values.
- *Validation* – It should be possible to validate the values of the attributes.

105.1.2**Entities**

- *Meta Type Service* – A service that provides a unified access point for meta type information.
- *Attribute* – A key/value pair.
- *PID* – A unique persistent ID, defined in configuration management.
- *Attribute Definition* – Defines a description, name, help text, and type information of an attribute.
- *Object Class Definition* – Defines the type of a datum. It contains a description and name of the type plus a set of AttributeDefinition objects.
- *Meta Type Provider* – Provides access to the object classes that are available for this object. Access uses the PID and a locale to find the best ObjectClassDefinition object.
- *Meta Type Information* – Provides meta type information for a bundle.

Figure 23 Class Diagram Meta Typing Service, *org.osgi.service.metatyping*

105.1.3

Operation

The Meta Type service defines a rich dynamic typing system for properties. The purpose of the type system is to allow reasonable User Interfaces to be constructed dynamically.

The type information is normally carried by the bundles themselves. Either by implementing the `MetaTypeProvider` interface or by carrying one or more XML resources in that define a number of Meta Types in the `OSGI-INF/metatype` directories. Additionally, a Meta Type service could have other sources.

The Meta Type Service provides unified access to Meta Types that are carried by the resident bundles. The Meta Type Service collects this information from the bundles and provides uniform access to it. A client can request the Meta Type Information associated with a particular bundle. The `MetaTypeInfo` object provides a list of `ObjectClassDefinition` objects for a bundle. These objects define all the information for a specific *object class*. An object class is a some descriptive information and a set of named attributes (which are key/value pairs).

Access to Object Class Definitions is qualified by a locale and a Persistent Identity (PID). This specification does not specify what the PID means. One application is OSGi Configuration Management where a PID is used by the Managed Service and Managed Service Factory services. In general, a PID should be regarded as the name of a variable where an Object Class Definition defines its type.

105.2 Attributes Model

The Framework uses the LDAP filter syntax for searching the Framework registry. The usage of the attributes in this specification and the Framework specification closely resemble the LDAP attribute model. Therefore, the names used in this specification have been aligned with LDAP. Consequently, the interfaces which are defined by this Specification are:

- `AttributeDefinition`
- `ObjectClassDefinition`
- `MetaTypeProvider`

These names correspond to the LDAP attribute model. For further information on ASN.1-defined attributes and X.500 object classes and attributes, see [25] *Understanding and Deploying LDAP Directory services*.

The LDAP attribute model assumes a global name-space for attributes, and object classes consist of a number of attributes. So, if an object class inherits the same attribute from different parents, only one copy of the attribute must become part of the object class definition. This name-space implies that a given attribute, for example `cn`, should *always* be the common name and the type must always be a `String`. An attribute `cn` cannot be an `Integer` in another object class definition. In this respect, the OSGi approach towards attribute definitions is comparable with the LDAP attribute model.

105.3 Object Class Definition

The `ObjectClassDefinition` interface is used to group the attributes which are defined in `AttributeDefinition` objects.

An `ObjectClassDefinition` object contains the information about the overall set of attributes and has the following elements:

- A name which can be returned in different locales.
- A global name-space in the registry, which is the same condition as LDAP/X.500 object classes. In these standards the OSI Object Identifier (OID) is used to uniquely identify object classes. If such an OID exists, (which can be requested at several standard organizations, and many companies already have a node in the tree) it can be returned here. Otherwise, a unique id should be returned. This id can be a Java class name (reverse domain name) or can be generated with a GUID algorithm. All LDAP-defined object classes already have an associated OID. It is strongly advised to define the object classes from existing LDAP schemes which provide many preexisting OIDs. Many such schemes exist ranging from postal addresses to DHCP parameters.
- A human-readable description of the class.
- A list of attribute definitions which can be filtered as required, or optional. Note that in X.500 the mandatory or required status of an attribute is part of the object class definition and not of the attribute definition.
- An icon, in different sizes.

105.4 Attribute Definition

The `AttributeDefinition` interface provides the means to describe the data type of attributes.

The `AttributeDefinition` interface defines the following elements:

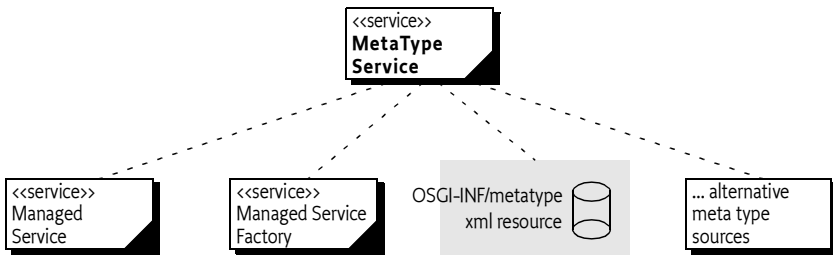
- Defined names (final ints) for the data types as restricted in the Framework for the attributes, called the syntax in OSI terms, which can be obtained with the `getType()` method.
- `AttributeDefinition` objects should use an ID that is similar to the OID as described in the ID field for `ObjectClassDefinition`.
- A localized name intended to be used in user interfaces.
- A localized description that defines the semantics of the attribute and possible constraints, which should be usable for tooltips.
- An indication if this attribute should be stored as a unique value, a Vector, or an array of values, as well as the maximum cardinality of the type.
- The data type, as limited by the Framework service registry attribute types.
- A validation function to verify if a possible value is correct.
- A list of values and a list of localized labels. Intended for popup menus in GUIs, allowing the user to choose from a set.
- A default value. The return type of this is a `String[]`. For cardinality = zero, this return type must be an array of one `String` object. For other cardinalities, the array must not contain more than the absolute value of *cardinality* `String` objects. In that case, it may contain 0 objects.

105.5 Meta Type Service

The Meta Type Service provides unified access to Meta Type information that is associated with a Bundle. It can get this information through the following means:

- *Meta Type Resource* – A bundle can provide one or more XML resources that are contained in its JAR file. These resources contain and XML definition of meta types as well as to what PIDs these Meta Types apply. These XML resources must reside in the `OSGI-INF/metatype` directories of the bundle (including any fragments).
- *ManagedService[Factory] objects* – As defined in the configuration management specification, `ManagedService` and `ManagedServiceFactory` service objects can optionally implement the `MetaTypeProvider` interface. The Meta Type Service will only search for `MetaTypeProvider` objects if no meta type resources are found in the bundle.

Figure 24 Sources for Meta Types



This model is depicted in Figure 24.

The Meta Type Service can therefore be used to retrieve meta type information for bundles which contain Meta Type resources or which provide their own MetaTypeProvider objects. The MetaTypeService interface has a single method:

- [getMetaTypeInfo\(Bundle\)](#) – Given a bundle, it must return the Meta Type Information for that bundle, even if there is no meta type information available at the moment of the call.

The returned MetaTypeInfo object maintains a map of PID to ObjectClassDefinition objects. The map is keyed by locale and PID. The list of maintained PIDs is available from the MetaTypeInfo object with the following methods:

- [getPids\(\)](#) – PIDs for which Meta Types are available. In the Configuration Admin service
- [getFactoryPids\(\)](#) – PIDs associated with Managed Service Factory services.

The MetaTypeInfo interface extends the MetaTypeProvider interface. The MetaTypeProvider interface is used to access meta type information. It supports locale dependent information so that the text used in AttributeDefinition and ObjectClassDefinition objects can be adapted to different locales.

Which locales are supported by the MetaTypeProvider object are defined by the implementer or the meta type resources. The list of available locales can be obtained from the MetaTypeProvider object.

The MetaTypeProvider interface provides the following methods:

- [getObjectClassDefinition\(String,String\)](#) – Get access to an ObjectClassDefinition object for the given PID. The second parameter defines the locale.
- [getLocales\(\)](#) – List the locales that are available.

Locale objects are represented in String objects because not all profiles support Locale. The String holds the standard Locale presentation of:

```

locale = language ( '_' country ( '_' variation?) ) ?
language ::= < defined by ISO 3166 >
country  ::= < defined by ISO 639 >
  
```


For example, `en`, `nl_BE`, `en_CA_posix` are valid locales. The use of null for locale indicates that `java.util.Locale.getDefault()` must be used.

The Meta Type Service implementation class is the main class. It registers the `org.osgi.service.metatype.MetaTypeService` service and has a method to get a `MetaTypeInfo` object for a bundle.

Following is some sample code demonstrating how to print out all the Object Class Definitions and Attribute Definitions contained in a bundle:

```
void printMetaTypes( MetaTypeService mts, Bundle b ) {
    MetaTypeInfo mti =
        mts.getMetaTypeInfo(b);
    String [] pids = mti.getPids();
    String [] factoryPids = mti.getFactoryPids();
    String [] locales = mti.getLocales();

    for ( int locale = 0; locales.length; locale++ ) {
        System.out.println("Locale " + locales[locale] );
        for (int i=0; i< pids.length; i++) {
            ObjectClassDefinition ocd =
                mti.getObjectClassDefinition(pids[i], null);
            AttributeDefinitions[] ads =
                ocd.getAttributeDefinitions(ALL);
            for (int j=0; j< ads.length; j++) {
                System.out.println("OCD="+ocd.getName()
                    + "AD="+ads[j].getName());
            }
        }
    }
}
```

105.6 Using the Meta Type Resources

A bundle that wants to provide meta type resources must place these resources in the `OSGI-INF/metatype`, the name of the resource must be a valid JAR path. All resources in that directory must be meta type documents. Fragments can contain additional meta type resources in the same directory and they must be taken into account when the meta type resources are searched.

The meta type resources must be encoded in UTF-8.

The MetaType Service must support localization of the

- name
- icon
- description
- label attributes

The localization mechanism must be identical using the same mechanism as described in the Core module layer, section *Localization* on page 64, using the same property resource. However, it is possible to override the property resource in the meta type definition resources with the localization attribute of the `MetaData` element.

The Meta Type Service must examine the bundle and its fragments to locate all localization resources for the localization base name. From that list, the Meta Type Service derives the list of locales which are available for the meta type information. This list can then be returned by `MetaTypeInfo.getLocales` method. This list can change at any time because the bundle could be refreshed. Clients should be prepared that this list changes after they received it.

105.6.1 XML Schema of a Meta Type Resource

This section describes the schema of the meta type resource. This schema is not intended to be used during runtime for validating meta type resources. The schema is intended to be used by tools and external management systems.

The XML name space for meta type documents must be:

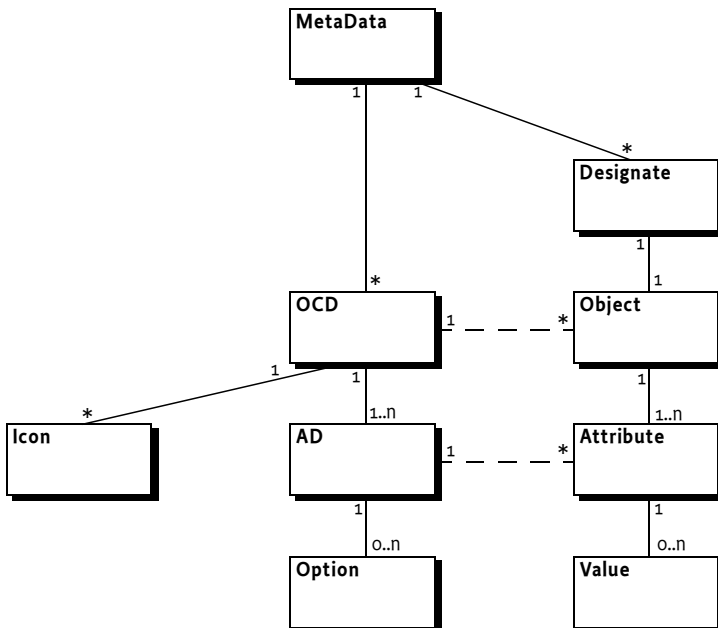
`http://www.osgi.org/xmlns/metatype/v1.0.0`

The name space abbreviation should be `metatype`. I.e. the following header should be:

```
<metatype:MetaData
  xmlns:metatype=
    "http://www.osgi.org/xmlns/metatype/v1.0.0"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
>
```

The file can be found in the `osgi.jar` file that can be downloaded from the www.osgi.org web site.

Figure 25 XML Schema Instance Structure (Type name = Element name)



The element structure of the XML file is:

```
MetaData ::= OCD* Designate*

OCD      ::= AD+ Icon ?
AD       ::= Option*

Designate ::= Object
Object    ::= Attribute *

Attribute ::= Value *
```

The different elements are described in Table 13.

Table 13 XML Schema for Meta Type resources

Attribute	Deflt	Type	Method	Description
MetaData				Top Element
localization		string		Points to the Properties file that can localize this XML. See <i>Localization</i> on page 64 of the Core book.
OCD				Object Class Definition
name	<>	string	getName()	A human readable name that can be localized.
description			getDescription()	A human readable description of the Object Class Definition that can be localized.
id	<>		getID()	A unique id, can not be localized.
Designate				An association between one PID and an Object Class Definition. This element <i>designates</i> a PID to be of a certain <i>type</i> .
pid	<>	string		The PID that is associated with an OCD. This can be a reference to a factory PID or a singleton PID depending on the factoryPid attribute.
factoryPid		string		If the factoryPid attribute is set, this Designate element defines a factory configuration for the given factory, if it is not set or empty, it designates a singleton configuration.
bundle		string		Mandatory location of the bundle that implements the PID. This binds the PID to the bundle. I.e. no other bundle using the same PID may use this designation.
optional	false	boolean		If true, then this Designate element is optional, errors during processing must be ignored.

Table 13 XML Schema for Meta Type resources

Attribute	Deflt	Type	Method	Description
merge	false	boolean		If the PID refers to an existing variable, then merge the properties with the existing properties if this attribute is true. Otherwise, replace the properties.
AD				Attribute Definition
name		string	getName()	A localizable name for the Attribute Definition. description
description		string	getDescription()	A localizable description for the Attribute Definition.
id			getID()	The unique ID of the Attribute Definition.
type		string	getType()	The type of an attribute is an enumeration of the different scalar types. The string is mapped to one of the constants on the AttributeDefinition interface. Valid values, which are defined in the Scalar type, are: <div><div>String ↔ STRING</div><div>Long ↔ LONG</div><div>Double ↔ DOUBLE</div><div>Float ↔ FLOAT</div><div>Integer ↔ INTEGER</div><div>Byte ↔ BYTE</div><div>Char ↔ CHARACTER</div><div>Boolean ↔ BOOLEAN</div><div>Short ↔ SHORT</div></div>
cardinality	0		getCardinality()	The number of elements an instance can take. Positive numbers describe an array ([]) and negative numbers describe a Vector object.
min		string	validate(String)	A validation value. This value is not directly available from the AttributeDefinition interface. However, the validate(String) method must verify this. The semantics of this field depend on the type of this Attribute Definition.
max		string	validate(String)	A validation value. Similar to the min field.

Table 13 XML Schema for Meta Type resources

Attribute	Deflt	Type	Method	Description
default		string	getDefaultValue()	The default value. A default is an array of String objects. The XML attribute must contain a comma delimited list. If the comma must be represented, it must be escaped with a back slash ('\u005c'). A back slash can be included with two backslashes. White spaces around the command and after/before an XML element must be ignored. For example: <pre>df1t="a\\,b,b\\,c, c\\,d" => ["a,b", "b,c", "c\\", "d"]</pre>
required	true	boolean		Required attributes
Option				One option label/value for the options in an AD.
label	<>	string	getOptionLabels()	The label
value	<>	string	getOptionValues()	The value
Icon				An icon definition.
resource	<>	string	getIcon(int)	The resource is a URL. The base URL is assumed to be the XML file with the definition. I.e. if the XML is a resource in the JAR file, then this URL can reference another resource in that JAR file using a relative URL.
size	<>	string	getIcon(int)	The number of pixels of the icon, maps to the size parameter of the getIcon(int) method.
Object				A definition of an instance.
ocdref	<>	string		A reference to the id attribute of an OCD element. I.e. this attribute defines the OCD type of this object.
Attribute				A value for an attribute of an object.
adref	<>	string		A reference to the id of the AD in the OCD as referenced by the parent Object.
content		string		The content of the attributes. If this is an array, the content must be separated by commas (',' \u002C). Commas must be escaped as described at the default attribute of the AD element. See default on page 139.

Table 13		XML Schema for Meta Type resources		
Attribute	Deftl	Type	Method	Description
Value				Holds a single value. This element can be repeated multiple times under an Attribute

105.6.2

Example Meta Data File

This example defines a meta type file for a Person record, based on ISO attribute types. I.e. the ids that are used are derived from ISO attributes.

```
<?xml version="1.0" encoding="UTF-8"?>
<metatype:MetaData
  xmlns:metatype=
    "http://www.osgi.org/xmlns/metatype/v1.0.0"
  >
  <MetaData localization="person">
    <OCD name="%person" id="2.5.6.6"
      description="%Person Record">
      <AD name="%sex" id="2.5.4.12" type="Integer">
        <Option label="%male" value="1"/>
        <Option label="%female" value="0"/>
      </AD>
      <AD name="%sn" id="2.5.4.4" type="String"/>
      <AD name="%cn" id="2.5.4.3" type="String"/>
      <AD name="%seeAlso" id="2.5.4.34" type="String"
        cardinality="8" default="http://www.google.com,
          http://www.yahoo.com"/>
      <AD name="%telNumber" id="2.5.4.20" type="String"/>
    </OCD>

    <Designate pid="com.acme.addressbook">
      <Object type="2.5.6.6"/>
    </Designate>
  </MetaData>
```

Translations for this file must be stored in the same directory as this meta type resource. The property files have the root name of person. The Dutch, French and English translations could look like:

```
person_du_NL.properties:
person=Persoon
person record=Persoons beschrijving
cn=Naam
sn=Voornaam
seeAlso=Zie ook
telNumber=Tel. Nummer
sex=Geslacht
male=Mannelijk
female=Vrouwelijk

person_fr.properties
```

```

person=Person
person record=Description un person
cn=Nom
sn=Surnom
seeAlso=Reference
telNumber=Tel.
sex=Sexe
male=Homme
female=Femme

person_en_US.properties
person=Person
person record=Person Record
cn=Name
sn=Sur Name
seeAlso=See Also
telNumber=Tel.
sex=Sex
male=Male
female=Female

```

105.7 Object

The OCD element can be used to describe the possible contents of a Dictionary object. In this case, the attribute name is the key. The Object element can be used to assign a value to a Dictionary object. This section contains a number of examples how values will be assigned from an Object element.

105.8 XML Schema

```

<schema xmlns="http://www.w3.org/2001/XMLSchema"
  targetNamespace="http://www.osgi.org/xmlns/metatype/v1.0.0"
  xmlns:metatype="http://www.osgi.org/xmlns/metatype/v1.0.0">
  <complexType name="MetaData">
    <sequence>
      <element name="OCD" type="metatype:OCD" minOccurs="0" maxOccurs="unbounded"/>
      <element name="Designate" type="metatype:Designate" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="localization" type="string" use="optional"/>
  </complexType>

  <complexType name="OCD">
    <sequence>
      <element name="AD" type="metatype:AD" minOccurs="1" maxOccurs="unbounded"/>
      <element name="Icon" type="metatype:Icon" minOccurs="0" maxOccurs="1"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
    <attribute name="description" type="string" use="optional"/>
    <attribute name="id" type="string" use="required"/>
  </complexType>

  <complexType name="AD">
    <sequence>
      <element name="Option" type="metatype:Option" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>

```

```

<attribute name="name" type="string" use="optional"/>
<attribute name="description" type="string" use="optional"/>
<attribute name="id" type="string" use="required"/>
<attribute name="type" type="metatype:Scalar" use="required"/>
<attribute name="cardinality" type="int" use="optional" default="0"/>
<attribute name="min" type="string" use="optional"/>
<attribute name="max" type="string" use="optional"/>
<attribute name="default" type="string" use="optional"/>
<attribute name="required" type="boolean" use="optional" default="true"/>
</complexType>

<complexType name="Object">
  <sequence>
    <element name="Attribute" type="metatype:Attribute" minOccurs="0" maxOccurs="unbounded"/>
  </sequence>
  <attribute name="ocdref" type="string" use="required"/>
</complexType>

<complexType name="Attribute">
  <attribute name="adref" type="string" use="required"/>
  <attribute name="content" type="string" use="required"/>
</complexType>

<complexType name="Designate">
  <sequence>
    <element name="Object" type="metatype:Object" minOccurs="1" maxOccurs="1"/>
  </sequence>
  <attribute name="pid" type="string" use="required"/>
  <attribute name="factoryPid" type="string" use="optional" default=""/>
  <attribute name="bundle" type="string" use="required"/>
  <attribute name="optional" type="boolean" default="false" use="optional"/>
  <attribute name="merge" type="boolean" default="false" use="optional"/>
</complexType>

<simpleType name="Scalar">
  <restriction base="string">
    <enumeration value="String"/>
    <enumeration value="Long"/>
    <enumeration value="Double"/>
    <enumeration value="Float"/>
    <enumeration value="Integer"/>
    <enumeration value="Byte"/>
    <enumeration value="Char"/>
    <enumeration value="Boolean"/>
    <enumeration value="Short"/>
  </restriction>
</simpleType>

<complexType name="Option">
  <attribute name="label" type="string" use="required"/>
  <attribute name="value" type="string" use="required"/>
</complexType>

<complexType name="Icon">
  <attribute name="resource" type="string" use="required"/>
  <attribute name="size" type="positiveInteger" use="required"/>
</complexType>

<element name="MetaData" type="metatype:MetaData"/>
</schema>

```

105.9 Limitations

The OSGi MetaType specification is intended to be used for simple applications. It does not, therefore, support recursive data types, mixed types in arrays/vectors, or nested arrays/vectors.

105.10 Related Standards

One of the primary goals of this specification is to make metatype information available at run-time with minimal overhead. Many related standards are applicable to metatypes; except for Java beans, however, all other metatype standards are based on document formats (e.g. XML). In the OSGi Service Platform, document format standards are deemed unsuitable due to the overhead required in the execution environment (they require a parser during run-time).

Another consideration is the applicability of these standards. Most of these standards were developed for management systems on platforms where resources are not necessarily a concern. In this case, a metatype standard is normally used to describe the data structures needed to control some other computer via a network. This other computer, however, does not require the metatype information as it is *implementing* this information.

In some traditional cases, a management system uses the metatype information to control objects in an OSGi Service Platform. Therefore, the concepts and the syntax of the metatype information must be mappable to these popular standards. Clearly, then, these standards must be able to describe objects in an OSGi Service Platform. This ability is usually not a problem, because the metatype languages used by current management systems are very powerful.

105.11 Security Considerations

Special security issues are not applicable for this specification.

105.12 Changes

The Metatype specification is significantly expanded by now actually providing a service. The following additions were made.

- The addition of a service that gathers Metatype information from bundles through an XML file as well as the original MetatypeProvider interface based on Managed Service and Managed Service Factory services. See *Meta Type Service* on page 133.
- A standardized XML schema to define Metatypes as well as related instances. See *XML Schema* on page 141.

105.13 org.osgi.service.metatype

The OSGi Metatype Package. Specification Version 1.1.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

```
Import-Package: org.osgi.service.metatype; version=1.1
```

105.13.1 Summary

- AttributeDefinition - An interface to describe an attribute. [p.144]
- MetaTypeInfo - A MetaType Information object is created by the MetaTypeService to return meta type information for a specific bundle. [p.147]
- MetaTypeProvider - Provides access to metatypes. [p.147]
- MetaTypeService - The MetaType Service can be used to obtain meta type information for a bundle. [p.148]
- ObjectClassDefinition - Description for the data type information of an objectclass. [p.148]

105.13.2 public interface AttributeDefinition

An interface to describe an attribute.

An AttributeDefinition object defines a description of the data type of a property/attribute.

105.13.2.1 public static final int BIGDECIMAL = 10

The BIGDECIMAL (10) type. Attributes of this type should be stored as Big-Decimal, Vector with BigDecimal or BigDecimal[] objects depending on getCardinality().

Deprecated Since 1.1

105.13.2.2 public static final int BIGINTEGER = 9

The BIGINTEGER (9) type. Attributes of this type should be stored as BigInteger, Vector with BigInteger or BigInteger[] objects, depending on the getCardinality() value.

Deprecated Since 1.1

105.13.2.3 public static final int BOOLEAN = 11

The BOOLEAN (11) type. Attributes of this type should be stored as Boolean, Vector with Boolean or boolean[] objects depending on getCardinality().

105.13.2.4 public static final int BYTE = 6

The BYTE (6) type. Attributes of this type should be stored as Byte, Vector with Byte or byte[] objects, depending on the getCardinality() value.

105.13.2.5 public static final int CHARACTER = 5

The CHARACTER (5) type. Attributes of this type should be stored as Character, Vector with Character or char[] objects, depending on the getCardinality() value.

105.13.2.6 public static final int DOUBLE = 7

The DOUBLE (7) type. Attributes of this type should be stored as Double, Vector with Double or double[] objects, depending on the getCardinality() value.

105.13.2.7	public static final int FLOAT = 8 The FLOAT (8) type. Attributes of this type should be stored as Float, Vector with Float or float[] objects, depending on the getCardinality() value.										
105.13.2.8	public static final int INTEGER = 3 The INTEGER (3) type. Attributes of this type should be stored as Integer, Vector with Integer or int[] objects, depending on the getCardinality() value.										
105.13.2.9	public static final int LONG = 2 The LONG (2) type. Attributes of this type should be stored as Long, Vector with Long or long[] objects, depending on the getCardinality() value.										
105.13.2.10	public static final int SHORT = 4 The SHORT (4) type. Attributes of this type should be stored as Short, Vector with Short or short[] objects, depending on the getCardinality() value.										
105.13.2.11	public static final int STRING = 1 The STRING (1) type. Attributes of this type should be stored as String, Vector with String or String[] objects, depending on the getCardinality() value.										
105.13.2.12	public int getCardinality() □ Return the cardinality of this attribute. The OSGi environment handles multi valued attributes in arrays ([]) or in Vector objects. The return value is defined as follows: <table><tr><td>x = Integer.MIN_VALUE</td><td>no limit, but use Vector</td></tr><tr><td>x < 0</td><td>-x = max occurrences, store in Vector</td></tr><tr><td>x > 0</td><td>x = max occurrences, store in array []</td></tr><tr><td>x = Integer.MAX_VALUE</td><td>no limit, but use array []</td></tr><tr><td>x = 0</td><td>1 occurrence required</td></tr></table> <i>Returns</i> The cardinality of this attribute.	x = Integer.MIN_VALUE	no limit, but use Vector	x < 0	-x = max occurrences, store in Vector	x > 0	x = max occurrences, store in array []	x = Integer.MAX_VALUE	no limit, but use array []	x = 0	1 occurrence required
x = Integer.MIN_VALUE	no limit, but use Vector										
x < 0	-x = max occurrences, store in Vector										
x > 0	x = max occurrences, store in array []										
x = Integer.MAX_VALUE	no limit, but use array []										
x = 0	1 occurrence required										
105.13.2.13	public String[] getDefaultValue() □ Return a default for this attribute. The object must be of the appropriate type as defined by the cardinality and getType(). The return type is a list of String objects that can be converted to the appropriate type. The cardinality of the return array must follow the absolute cardinality of this type. E.g. if the cardinality = 0, the array must contain 1 element. If the cardinality is 1, it must contain 0 or 1 elements. If it is -5, it must contain from 0 to max 5 elements. Note that the special case of a 0 cardinality, meaning a single value, does not allow arrays or vectors of 0 elements. <i>Returns</i> Return a default value or null if no default exists.										

105.13.2.14 public String getDescription()

- Return a description of this attribute. The description may be localized and must describe the semantics of this type and any constraints.

Returns The localized description of the definition.

105.13.2.15 public String getID()

- Unique identity for this attribute. Attributes share a global namespace in the registry. E.g. an attribute cn or commonName must always be a String and the semantics are always a name of some object. They share this aspect with LDAP/X.500 attributes. In these standards the OSI Object Identifier (OID) is used to uniquely identify an attribute. If such an OID exists, (which can be requested at several standard organisations and many companies already have a node in the tree) it can be returned here. Otherwise, a unique id should be returned which can be a Java class name (reverse domain name) or generated with a GUID algorithm. Note that all LDAP defined attributes already have an OID. It is strongly advised to define the attributes from existing LDAP schemes which will give the OID. Many such schemes exist ranging from postal addresses to DHCP parameters.

Returns The id or oid

105.13.2.16 public String getName()

- Get the name of the attribute. This name may be localized.

Returns The localized name of the definition.

105.13.2.17 public String[] getOptionLabels()

- Return a list of labels of option values.

The purpose of this method is to allow menus with localized labels. It is associated with `getOptionValues`. The labels returned here are ordered in the same way as the values in that method.

If the function returns null, there are no option labels available.

This list must be in the same sequence as the `getOptionValues()` method. I.e. for each index *i* in `getOptionLabels`, *i* in `getOptionValues()` should be the associated value.

For example, if an attribute can have the value male, female, unknown, this list can return (for dutch) `new String[] { "Man", "Vrouw", "Onbekend" }`.

Returns A list values

105.13.2.18 public String[] getOptionValues()

- Return a list of option values that this attribute can take.

If the function returns null, there are no option values available.

Each value must be acceptable to `validate()` (return "") and must be a String object that can be converted to the data type defined by `getType()` for this attribute.

This list must be in the same sequence as `getOptionLabels()`. I.e. for each index *i* in `getOptionValues`, *i* in `getOptionLabels()` should be the label.

For example, if an attribute can have the value male, female, unknown, this list can return `new String[] { "male", "female", "unknown" }`.

Returns A list values

105.13.2.19 **public int getType()**

- Return the type for this attribute.

Defined in the following constants which map to the appropriate Java type. STRING, LONG, INTEGER, CHAR, BYTE, DOUBLE, FLOAT, BOOLEAN.

Returns The type for this attribute.

105.13.2.20 **public String validate(String value)**

value The value before turning it into the basic data type

- Validate an attribute in String form. An attribute might be further constrained in value. This method will attempt to validate the attribute according to these constraints. It can return three different values:

null	No validation present
" "	No problems detected
"..."	A localized description of why the value is wrong

Returns null, "", or another string

105.13.3 **public interface MetaTypeInfo extends MetaTypeProvider**

A MetaType Information object is created by the MetaTypeService to return meta type information for a specific bundle.

Since 1.1

105.13.3.1 **public Bundle getBundle()**

- Return the bundle for which this object provides meta type information.

Returns Bundle for which this object provides meta type information.

105.13.3.2 **public String[] getFactoryPids()**

- Return the Factory PIDs (for ManagedServiceFactories) for which Object-ClassDefinition information is available.

Returns Array of Factory PIDs.

105.13.3.3 **public String[] getPids()**

- Return the PIDs (for ManagedServices) for which ObjectClassDefinition information is available.

Returns Array of PIDs.

105.13.4 **public interface MetaTypeProvider**

Provides access to metatypes.

105.13.4.1 **public String[] getLocales()**

- Return a list of available locales. The results must be names that consists of language [_ country [_ variation]] as is customary in the Locale class.

Returns An array of locale strings or null if there is no locale specific localization can be found.

105.13.4.2 `public ObjectClassDefinition getObjectClassDefinition(String id, String locale)`

id The ID of the requested object class. This can be a pid or factory pid returned by getPids or getFactoryPids.

locale The locale of the definition or null for default locale.

- Returns an object class definition for the specified id localized to the specified locale.

The locale parameter must be a name that consists of language[“_” country[“_” variation]] as is customary in the Locale class. This Locale class is not used because certain profiles do not contain it.

Returns A ObjectClassDefinition object.

Throws IllegalArgumentException – If the id or locale arguments are not valid

105.13.5 `public interface MetaTypeService`

The MetaType Service can be used to obtain meta type information for a bundle. The MetaType Service will examine the specified bundle for meta type documents to create the returned MetaTypeInfo object.

If the specified bundle does not contain any meta type documents, then a MetaTypeInfo object will be returned that wrappers any ManagedService or ManagedServiceFactory services registered by the specified bundle that implement MetaTypeProvider. Thus the MetaType Service can be used to retrieve meta type information for bundles which contain a meta type documents or which provide their own MetaTypeProvider objects.

Since 1.1

105.13.5.1 `public static final String METATYPE_DOCUMENTS_LOCATION = “OSGI-INF/metatype”`

Location of meta type documents. The MetaType Service will process each entry in the meta type documents directory.

105.13.5.2 `public MetaTypeInfo getMetaTypeInfo(Bundle bundle)`

bundle The bundle for which meta type information is requested.

- Return the MetaType information for the specified bundle.

Returns A MetaTypeInfo object for the specified bundle.

105.13.6 `public interface ObjectClassDefinition`

Description for the data type information of an objectclass.

105.13.6.1 `public static final int ALL = -1`

Argument for getAttributeDefinitions(int).

ALL indicates that all the definitions are returned. The value is -1.

105.13.6.2 public static final int OPTIONAL = 2

Argument for `getAttributeDefinitions(int)`.

OPTIONAL indicates that only the optional definitions are returned. The value is 2.

105.13.6.3 public static final int REQUIRED = 1

Argument for `getAttributeDefinitions(int)`.

REQUIRED indicates that only the required definitions are returned. The value is 1.

105.13.6.4 public AttributeDefinition[] getAttributeDefinitions(int filter)

filter ALL,REQUIRED,OPTIONAL

- Return the attribute definitions for this object class.

Return a set of attributes. The filter parameter can distinguish between ALL, REQUIRED or the OPTIONAL attributes.

Returns An array of attribute definitions or null if no attributes are selected

105.13.6.5 public String getDescription()

- Return a description of this object class. The description may be localized.

Returns The description of this object class.

105.13.6.6 public InputStream getIcon(int size) throws IOException

size Requested size of an icon, e.g. a 16x16 pixels icon then size = 16

- Return an InputStream object that can be used to create an icon from.

Indicate the size and return an InputStream object containing an icon. The returned icon maybe larger or smaller than the indicated size.

The icon may depend on the localization.

Returns An InputStream representing an icon or null

Throws IOException – If the InputStream cannot be returned.

105.13.6.7 public String getID()

- Return the id of this object class.

ObjectDefintion objects share a global namespace in the registry. They share this aspect with LDAP/X.500 attributes. In these standards the OSI Object Identifier (OID) is used to uniquely identify object classes. If such an OID exists, (which can be requested at several standard organisations and many companies already have a node in the tree) it can be returned here. Otherwise, a unique id should be returned which can be a java class name (reverse domain name) or generated with a GUID algorithm. Note that all LDAP defined object classes already have an OID associated. It is strongly advised to define the object classes from existing LDAP schemes which will give the OID for free. Many such schemes exist ranging from postal addresses to DHCP parameters.

Returns The id of this object class.

105.13.6.8 public String getName()

- Return the name of this object class. The name may be localized.

Returns The name of this object class.

105.14 References

- [24] *LDAP*.
Available at <http://directory.google.com/Top/Computers/Software/Internet/Servers/Directory/LDAP>
- [25] *Understanding and Deploying LDAP Directory services*
Timothy Howes et. al. ISBN 1-57870-070-1, MacMillan Technical publishing.

108 Wire Admin Service Specification

Version 1.0

108.1 Introduction

The Wire Admin service is an administrative service that is used to control a wiring topology in the OSGi Service Platform. It is intended to be used by user interfaces or management programs that control the wiring of services in an OSGi Service Platform.

The Wire Admin service plays a crucial role in minimizing the amount of context-specific knowledge required by bundles when used in a large array of configurations. The Wire Admin service fulfills this role by dynamically *wiring* services together. Bundles participate in this wiring process by registering services that produce or consume data. The Wire Admin service *wires* the services that produce data to services which consume data.

The purpose of wiring services together is to allow configurable cooperation of bundles in an OSGi Service Platform. For example, a temperature sensor can be connected to a heating module to provide a controlled system.

The Wire Admin service is a very important OSGi configuration service and is designed to cooperate closely with the Configuration Admin service, as defined in *Configuration Admin Service Specification* on page 63.

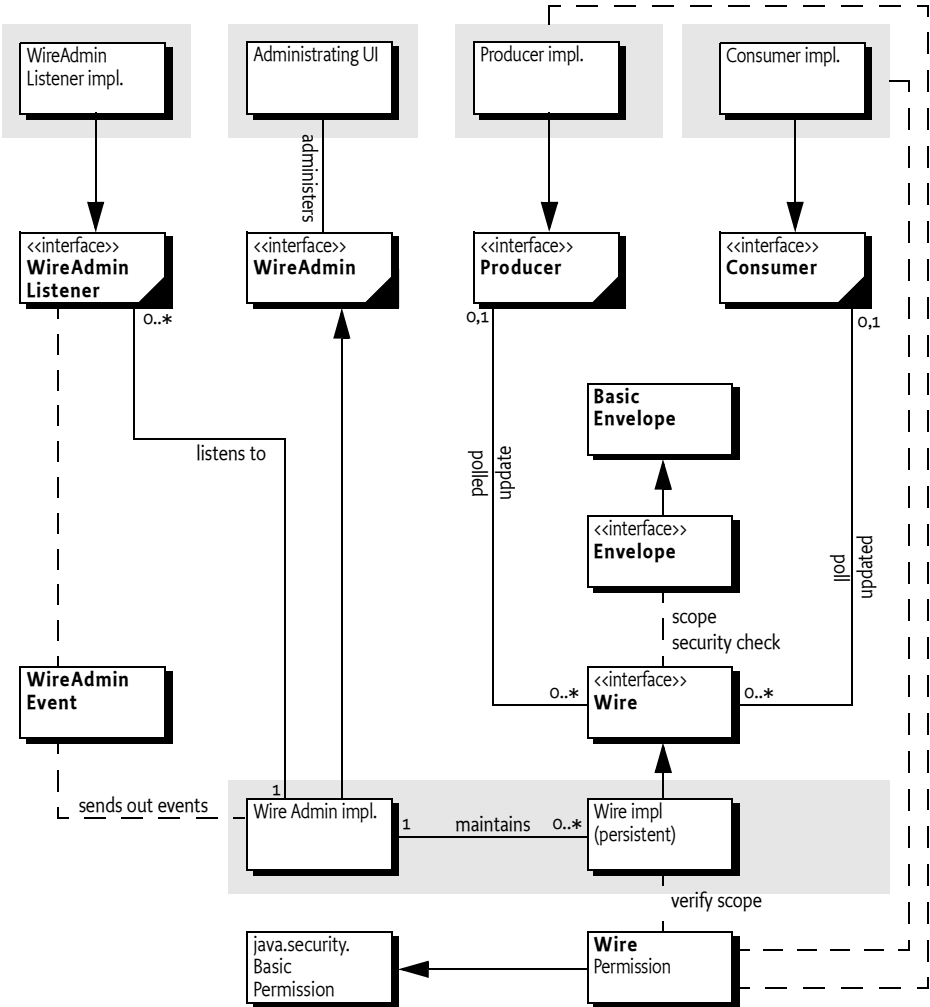
108.1.1 Wire Admin Service Essentials

- *Topology Management* – Provide a comprehensive mechanism to link data-producing components with data-consuming components in an OSGi environment.
- *Configuration Management* – Contains configuration data in order to allow either party to adapt to the special needs of the wire.
- *Data Type Handling* – Facilitate the negotiation of the data type to be used for data transfer between producers of data and consumers of data. Consumers and producers must be able to handle multiple data types for data exchanges using a preferred order.
- *Composites* – Support producers and consumers that can handle a large number of data items.
- *Security* – Separate connected parties from each other. Each party must not be required to hold the service object of the other party.
- *Simplicity* – The interfaces should be designed so that both parties, the Producer and the Consumer services, should be easy to implement.

108.1.2**Wire Admin Service Entities**

- *Producer* – A service object that generates information to be used by a Consumer service.
- *Consumer* – A service object that receives information generated by a Producer service.
- *Wire* – An object created by the Wire Admin service that defines an association between a Producer service and a Consumer service. Multiple Wire objects can exist between the same Producer and Consumer pair.
- *WireAdmin* – The service that provides methods to create, update, remove, and list Wire objects.
- *WireAdminListener* – A service that receives events from the Wire Admin service when the Wire object is manipulated or used.
- *WireAdminEvent* – The event that is sent to a WireAdminListener object, describing the details of what happened.
- *Configuration Properties* – Properties that are associated with a Wire object and that contain identity and configuration information set by the administrator of the Wire Admin service.
- *PID* – The Persistent IDentity as defined in the Configuration Admin specification.
- *Flavors* – The different data types that can be used to exchange information between Producer and Consumer services.
- *Composite Producer/Consumer* – A Producer/Consumer service that can generate/accept different kinds of values.
- *Envelope* – An interface for objects that can identify a value that is transferred over the wire. Envelope objects contain also a scope name that is used to verify access permissions.
- *Scope* – A set of names that categorizes the kind of values contained in Envelope objects for security and selection purposes.
- *Basic Envelope* – A concrete implementation of the Envelope interface.
- *WirePermission* – A Permission sub-class that is used to verify if a Consumer service or Producer service has permission for specific scope names.
- *Composite Identity* – A name that is agreed between a composite Consumer and Producer service to identify the kind of objects that they can exchange.

Figure 26 Class Diagram, *org.osgi.service.wiring*



108.1.3 Operation Summary

The Wire Admin service maintains a set of persistent Wire objects. A Wire object contains a Persistent IDentity (PID) for a Consumer service and a PID for a Producer service. (Wire objects can therefore be created when the Producer or Consumer service is not registered.)

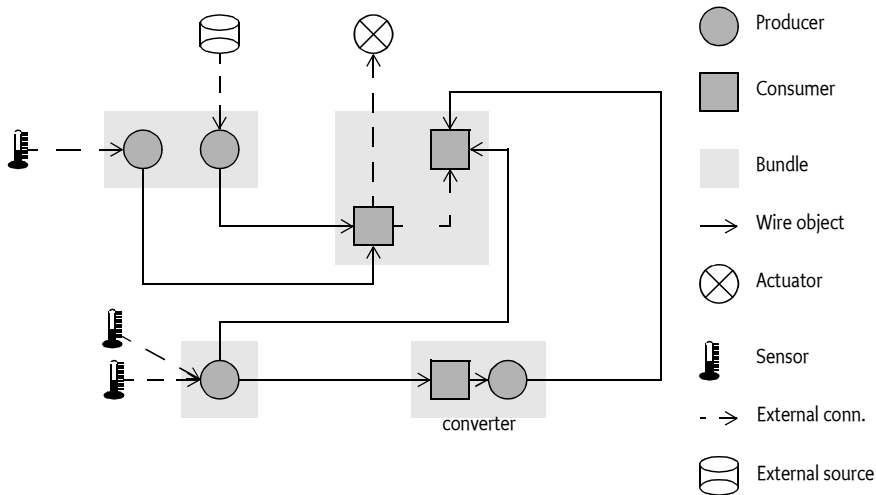
If both those Producer and Consumer services are registered with the Framework, they are connected by the Wire Admin service. The Wire Admin service calls a method on each service object and provides the list of Wire objects to which they are connected.

When a Producer service has new information, it should send this information to each of the connected Wire objects. Each Wire object then must check the filtering and security. If both filtering and security allow the transfer, the Producer service should inform the associated Consumer service with the new information. The Consumer services can also poll a Wire object for an new value at any time.

When a Consumer or Producer service is unregistered from the OSGi Framework, the other object in the association is informed that the Wire object is no longer valid.

Administrative applications can use the Wire Admin service to create and delete wires. These changes are immediately reflected in the current topology and are broadcast to Wire Admin Listener services.

Figure 27 An Example Wiring Scheme in an OSGi Environment



108.2 Producer Service

A Producer is a service that can produce a sequence of data objects. For example, a Producer service can produce, among others, the following type of objects:

- Measurement objects that represent a sensor measurement such as temperature, movement, or humidity.
- A String object containing information for user consumption, such as headlines.
- A Date object indicating the occurrence of a periodic event.
- Position information.
- Envelope objects containing status items which can be any type.

108.2.1 Producer Properties

A Producer service must be registered with the OSGi Framework under the interface name `org.osgi.service.wireadmin.Producer`. The following service properties must be set:

- `service.pid` – The value of this property, also known as the PID, defines the Persistent IDentity of a service. A Producer service must always use the same PID value whenever it is registered. The PID value allows the Wire Admin service to consistently identify the Producer service and create a persistent Wire object that links a Producer service to a Consumer service. See [26] *Design Patterns* specification for the rules regarding PIDs.
- `wireadmin.producer.flavors` – The value of this property is an array of Class objects (Class[]) that are the classes of the objects the service can produce. See *Flavors* on page 169 for more information about the data type negotiation between Producer and Consumer services.
- `wireadmin.producer.filters` – This property indicates to the Wire Admin service that this Producer service performs its own update filtering, meaning that the consumer can limit the number of update calls with a filter expression. This does not modify the data; it only determines whether an update via the wire occurs. If this property is not set, the Wire object must filter according to the description in *Composite objects* on page 161. This service registration property does not need to have a specific value.
- `wireadmin.producer.scope` – Only for a composite Producer service, a list of scope names that define the scope of this Producer service, as explained in *Scope* on page 162.
- `wireadmin.producer.composite` – List the composite identities of Consumer services with which this Producer service can interoperate. This property is of type String[]. A composite Consumer service can interoperate with a composite Producer service when there is at least one name that occurs in both the Consumer service's array and the Producer service's array for this property.

108.2.2

Connections

The Wire Admin service connects a Producer service and a Consumer service by creating a Wire object. If the Consumer and Producer services that are bound to a Wire object are registered with the Framework, the Wire Admin service must call the `consumersConnected(Wire[])` method on the Producer service object. Every change in the Wire Admin service that affects the Wire object to which a Producer service is connected must result in a call to this method. This requirement ensures that the Producer object is informed of its role in the wiring topology. If the Producer service has no Wire objects attached when it is registered, the Wire Admin service must always call `consumersConnected(null)`. This situation implies that a Producer service can assume it always gets called back from the Wire Admin service when it registers.

108.2.3

Producer Example

The following example shows a clock producer service that sends out a Date object every second.

```
public class Clock extends Thread implements Producer {
    Wire                wires[];
    BundleContext       context;
    boolean             quit;
```

```

Clock( BundleContext context ) {
    this.context = context;
    start();
}
public synchronized void run() {
    Hashtable p = new Hashtable();
    p.put( org.osgi.service.wireadmin.WireConstants.
        WIREADMIN_PRODUCER_FLAVORS,
        new Class[] { Date.class } );
    p.put( org.osgi.framework.Constants.SERVICE_PID,
        "com.acme.clock" );
    context.registerService(
        Producer.class.getName(), this, p );

    while( ! quit )
    try {
        Date now = new Date();
        for( int i=0; wires!=null && i<wires.length; i++ )
            wires[i].update( now );
        wait( 1000 );
    }
    catch( InterruptedException ie) {
        /* will recheck quit */
    }
}
public void synchronized consumersConnected(Wire wires[])
{
    this.wires = wires;
}
public Object polled(Wire wire) { return new Date(); }
...
}

```

108.2.4 Push and Pull

Communication between Consumer and Producer services can be initiated in one of the following ways.

- The Producer service calls the [update\(Object\)](#) method on the Wire object. The Wire object implementation must then call the [updated\(Wire,Object\)](#) method on the Consumer service, if the filtering allows this.
- The Consumer service can call [poll\(\)](#) on the Wire object. The Wire object must then call [polled\(Wire\)](#) on the Producer object. Update filtering must not apply to polling.

108.2.5 Producers and Flavors

Consumer services can only understand specific data types, and are therefore restricted in what data they can process. The acceptable object classes, the flavors, are communicated by the Consumer service to the Wire Admin service using the Consumer service's service registration properties. The

method `getFlavors()` on the Wire object returns this list of classes. This list is an ordered list in which the first class is the data type that is the most preferred data type supported by the Consumer service. The last class is the least preferred data type. The Producer service must attempt to convert its data into one of the data types according to the preferred order, or will return null from the poll method to the Consumer service if none of the types are recognized.

Classes cannot be easily compared for equivalence. Sub-classes and interfaces allow classes to masquerade as other classes. The `Class.isAssignableFrom(Class)` method verifies whether a class is type compatible, as in the following example:

```
Object polled(Wire wire) {
    Class clazzes[] = wire.getFlavors();
    for ( int i=0; i<clazzes.length; i++ ) {
        Class clazz = clazzes[i];
        if ( clazz.isAssignableFrom( Date.class ) )
            return new Date();
        if ( clazz.isAssignableFrom( String.class ) )
            return new Date().toString();
    }
    return null;
}
```

The order of the if statements defines the preferences of the Producer object. Preferred data types are checked first. This order normally works as expected but in rare cases, sub-classes can change it. Normally, however, that is not a problem.

108.3 Consumer Service

A Consumer service is a service that receives information from one or more Producer services and is wired to Producer services by the Wire Admin service. Typical Consumer services are as follows:

- The control of an actuator, such as a heating element, oven, or electric shades
- A display
- A log
- A state controller such as an alarm system

108.3.1 Consumer Properties

A Consumer service must be registered with the OSGi Framework under the interface name `org.osgi.service.wireadmin.Consumer`. The following service properties must be set:

- `service.pid` – The value of this property, also known as the PID, defines the Persistent IDentity of a service. A Consumer service must always use the same PID value whenever it is registered. The PID value allows the Wire Admin service to consistently identify the Consumer service and create a persistent Wire object that links a Producer service to a Con-

sumer service. See the Configuration Admin specification for the rules regarding PIDs.

- `wireadmin.consumer.flavors` – The value of this property is an array of Class objects (`Class[]`) that are the acceptable classes of the objects the service can process. See *Flavors* on page 169 for more information about the data type negotiation between Producer and Consumer services.
- `wireadmin.consumer.scope` – Only for a composite Consumer service, a list of scope names that define the scope of this Consumer service, as explained in *Scope* on page 162.
- `wireadmin.consumer.composite` – List the composite identities of Producer services that this Consumer service can interoperate with. This property is of type `String[]`. A composite Consumer service can interoperate with a composite Producer service when at least one name occurs in both the Consumer service's array and the Producer service's array for this property.

108.3.2 Connections

When a Consumer service is registered and a Wire object exists that associates it to a registered Producer service, the `producersConnected(Wire[])` method is called on the Consumer service.

Every change in the Wire Admin service that affects a Wire object to which a Consumer service is connected must result in a call to the `producersConnected(Wire[])` method. This rule ensures that the Consumer object is informed of its role in the wiring topology. If the Consumer service has no Wire objects attached, the argument to the `producersConnected(Wire[])` method must be null. This method must also be called when a Producer service registers for the first time and no Wire objects are available.

108.3.3 Consumer Example

For example, a service can implement a Consumer service that logs all objects that are sent to it in order to allow debugging of a wiring topology.

```
public class LogConsumer implements Consumer {
    public LogConsumer( BundleContext context ) {
        Hashtable ht = new Hashtable();
        ht.put(
            Constants.SERVICE_PID, "com.acme.logconsumer" );
        ht.put( WireConstants.WIREADMIN_CONSUMER_FLAVORS,
            new Class[] { Object.class } );
        context.registerService( Consumer.class.getName(),
            this, ht );
    }
    public void updated( Wire wire, Object o ) {
        getLog().log( LogService.LOG_INFO, o.toString() );
    }
    public void producersConnected( Wire [] wires) {}
    LogService getLog() { ... }
}
```


108.3.4 Polling or Receiving a Value

When the Producer service produces a new value, it calls the `update(Object)` method on the Wire object, which in turn calls the `updated(Wire, Object)` method on the Consumer service object. When the Consumer service needs a value immediately, it can call the `poll()` method on the Wire object which in turn calls the `polled(Wire)` method on the Producer service.

If the `poll()` method on the Wire object is called and the Producer is unregistered, it must return a null value.

108.3.5 Consumers and Flavors

Producer objects send objects of different data types through Wire objects. A Consumer service object should offer a list of preferred data types (classes) in its service registration properties. The Producer service, however, can still send a null object or an object that is not of the preferred types. Therefore, the Consumer service must check the data type and take the appropriate action. If an object type is incompatible, then a log message should be logged to allow the operator to correct the situation.

The following example illustrates how a Consumer service can handle objects of type Date, Measurement, and String.

```
void process( Object in ) {
    if ( in instanceof Date )
        processDate( (Date) in );
    else if ( in instanceof Measurement )
        processMeasurement( (Measurement) in );
    else if ( in instanceof String )
        processString( (String) in );
    else
        processError( in );
}
```

108.4 Implementation issues

The Wire Admin service can call the `consumersConnected` or `producersConnected` methods during the registration of the Consumer or Producer service. Care should be taken in this method call so that no variables are used that are not yet set, such as the `ServiceRegistration` object that is returned from the registration. The same is true for the `updated` or `polled` callback because setting the Wire objects on the Producer service causes such a callback from the `consumersConnected` or `producersConnected` method.

A Wire Admin service must call the `producersConnected` and `consumersConnected` method asynchronously from the registrations, meaning that the Consumer or Producer service can use synchronized to restrict access to critical variables.

When the Wire Admin service is stopped, it must disconnect all connected consumers and producers by calling `producersConnected` and `consumersConnected` with a null for the wires parameter.

108.5 Wire Properties

A Wire object has a set of properties (a Dictionary object) that configure the association between a Consumer service and a Producer service. The type and usage of the keys, as well as the allowed types for the values are defined in *Configuration Properties* on page 70.

The Wire properties are explained in Table 14.

Table 14 *Standard Wire Properties*

Constant	Description
WIREADMIN_PID	The value of this property is a unique Persistent IDentity as defined in chapter 104 <i>Configuration Admin Service Specification</i> . This PID must be automatically created by the Wire Admin service for each new Wire object.
WIREADMIN_PRODUCER_PID	The value of the property is the PID of the Producer service.
WIREADMIN_CONSUMER_PID	The value of this property is the PID of the Consumer service.
WIREADMIN_FILTER	The value of this property is an OSGi filter string that is used to control the update of produced values. This filter can contain a number of attributes as explained in <i>Wire Flow Control</i> on page 165.

The properties associated with a Wire object are not limited to the ones defined in Table 14. The Dictionary object can also be used for configuring *both* Consumer services and Producer services. Both services receive the Wire object and can inspect the properties and adapt their behavior accordingly.

108.5.1 Display Service Example

In the following example, the properties of a Wire object, which are set by the Operator or User, are used to configure a Producer service that monitors a user's email account regularly and sends a message when the user has received email. This WireMail service is illustrated as follows:

```
public class WireMail extends Thread
    implements Producer {
    Wire                wires[];
    BundleContext      context;
    boolean            quit;

    public void start( BundleContext context ) {
        Hashtable      ht = new Hashtable();
        ht.put( Constants.SERVICE_PID, "com.acme.wiremail" );
        ht.put( WireConstants.WIREADMIN_PRODUCER_FLAVORS,
            new Class[] { Integer.class } );
        context.registerService( this,
            Producer.class.getName(),
            ht );
    }
}
```

```

    public synchronized void consumersConnected(
        Wire wires[] ) {
        this.wires = wires;
    }
    public Object polled( Wire wire ) {
        Dictionary p = wire.getProperties();
        // The password should be
        // obtained from User Admin Service
        int n = getNrMails(
            p.get( "userid" ),
            p.get( "mailhost" ) );
        return new Integer( n );
    }
    public synchronized void run() {
        while ( !quit )
            try {
                for ( int i=0; wires != null && i<wires.length;i++ )
                    wires[i].update( polled( wires[i] ) );

                wait( 150000 );
            }
            catch( InterruptedException e ) { break; }
    }
    ...
}

```

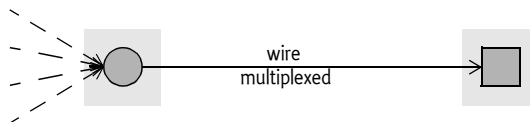
108.6 Composite objects

A Producer and/or Consumer service for each information item is usually the best solution. This solution is not feasible, however, when there are hundreds or thousands of information items. Each registered Consumer or Producer service carries the overhead of the registration, which may overwhelm a Framework implementation on smaller platforms.

When the size of the platform is an issue, a Producer and a Consumer service should abstract a larger number of information items. These Consumer and Producer services are called *composite*.

Figure 28

Composite Producer Example



Composite Producer and Consumer services should register respectively the [WIREADMIN_PRODUCER_COMPOSITE](#) and [WIREADMIN_CONSUMER_COMPOSITE](#) *composite identity* property with their service registration. These properties should contain a list of composite identities. These identities are not defined here, but are up to a mutual agreement between the Consumer and Producer service. For example, a composite identity could be MOST-1.5 or GSM-Phase2-Terminal. The

name may follow any scheme but will usually have some version information embedded. The composite identity properties are used to match Consumer and Producer services with each other during configuration of the Wire Admin service. A Consumer and Producer service should interoperate when at least one equal composite identity is listed in both the Producer and Consumer composite identity service property.

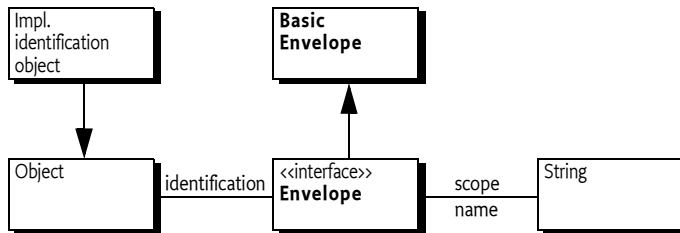
Composite producers/consumers must identify the *kind* of objects that are transferred over the Wire object, where *kind* refers to the intent of the object, not the data type. For example, a Producer service can represent the status of a door-lock and the status of a window as a boolean. If the status of the window is transferred as a boolean to the Consumer service, how would it know that this boolean represents the window and not the door-lock?

To avoid this confusion, the Wire Admin service includes an Envelope interface. The purpose of the Envelope interface is to associate a value object with:

- An identification object
- A scope name

Figure 29

Envelope



108.6.1 Identification

The Envelope object's identification object is used to identify the value carried in the Envelope object. Each unique kind of value must have its own unique identification object. For example, a left-front-window should have a different identification object than a rear-window.

The identification is of type Object. Using the [Object](#) class allows String objects to be used, but also makes it possible to use more complex objects. These objects can convey information in a way that is mutually agreed between the Producer and Consumer service. For example, its type may differ depending on each kind of value so that the *Visitor* pattern, see [26] *Design Patterns*, can be used. Or it may contain specific information that makes the Envelope object easier to dispatch for the Consumer service.

108.6.2 Scope

The scope name is a String object that *categorizes* the Envelope object. The scope name is used to limit the kind of objects that can be exchanged between composite Producer and Consumer services, depending on security settings.

The name-space for this scope should be mutually agreed between the Consumer and Producer services a priori. For the Wire Admin service, the scope name is an opaque string, though its syntax is specified in *Scope name syntax* on page 165.

Both composite Producer and Consumer services must add a list of their supported scope names to the service registration properties. This list is called the *scope* of that service. A Consumer service must add this scope property with the name of `WIREADMIN_CONSUMER_SCOPE`, a Producer service must add this scope property with the name `WIREADMIN_PRODUCER_SCOPE`. The type of this property must be a `String[]` object.

Not registering this property by the Consumer or the Producer service indicates to the Wire Admin service that any Wire object connected to that service must return null for the `Wire.getScope()` method. This case must be interpreted by the Consumer or Producer service that no scope verification is taking place. Secure Producer services should not produce values for this Wire object and secure Consumer services should not accept values.

It is also allowed to register with a *wildcard*, indicating that all scope names are supported. In that case, the `WIREADMIN_SCOPE_ALL` (which is `String[] { "*" }`) should be registered as the scope of the service. The Wire object's scope is then fully defined by the other service connected to the Wire object.

The following example shows how a scope is registered.

```
static String [] scope = { "DoorLock", "DoorOpen", "VIN" };

public void start( BundleContext context ) {
    Dictionary properties = new Hashtable();
    properties.put(
        WireConstants.WIREADMIN_CONSUMER_SCOPE,
        scope );
    properties.put( WireConstants.WIREADMIN_CONSUMER_PID,
        "com.acme.composite.consumer" );
    properties.put(
        WireConstants.WIREADMIN_CONSUMER_COMPOSITE,
        new String[] { "OSGiSP-R3" } );
    context.registerService( Consumer.class.getName(),
        new AcmeConsumer(),
        properties );
}
```

Both a composite Consumer and Producer service must register a scope to receive scope support from the Wire object. These two scopes must be converted into a single Wire object's scope and scope names in this list must be checked for the appropriate permissions. This resulting scope is available from the `Wire.getScope()` method.

If no scope is set by either the Producer or the Consumer service the result must be null. In that case, the Producer or Consumer service must assume that no security checking is in place. A secure Consumer or Producer service should then refuse to operate with that Wire object.

Otherwise, the resulting scope is the intersection of the Consumer and Producer service scope where each name in the scope, called *m*, must be implied by a `WirePermission[m,CONSUME]` of the Consumer service, and `WirePermission[m,PRODUCE]` of the Producer service.

If either the Producer or Consumer service has registered a wildcard scope then it must not restrict the list of the other service, except for the permission check. If both the Producer and Consumer service registered a wildcard, the resulting list must be `WIREADMIN_SCOPE_ALL` (`String[]{"*"}`).

For example, the Consumer service has registered a scope of `{A,B,C}` and has `WirePermission[*,CONSUME]`. The Producer service has registered a scope of `{B,C,E}` and has `WirePermission[C|E, PRODUCE,]`. The resulting scope is then `{C}`. Table 15 shows this and more examples.

Table 15

Examples of scope calculation. *C=Consumer, P=Producer, p=WirePermission, s=scope*

Cs	Cp	Ps	Pp	Wire Scope
null		null		null
{A,B,C}	*	null		null
null		{C,D,E}		null
{A,B,C}	B C	{A,B,C}	A B	{B}
*	*	{A,B,C}	A B C	{A,B,C}
*	*	*	*	{*}
{A,B,C}	A B C	{A,B,C}	X	{}
{A,B,C}	*	{B,C,E}	C E	{C}

The Wire object's scope must be calculated only once, when both the Producer and Consumer service become connected. When a Producer or Consumer service subsequently modifies its scope, the Wire object must *not* modify the original scope. A Consumer and a Produce service can thus assume that the scope does not change after the `producersConnected` method or `consumersConnected` method has been called.

108.6.3

Access Control

When an `Envelope` object is used as argument in `Wire.update(Object)` then the Wire object must verify that the `Envelope` object's scope name is included in the Wire object's scope. If this is not the case, the update must be ignored (the updated method on the Consumer service must not be called).

A composite Producer represents a number of values, which is different from a normal Producer that can always return a single object from the `poll` method. A composite Producer must therefore return an array of `Envelope` objects (`Envelope[]`). This array must contain `Envelope` objects for all the values that are in the Wire object's scope. It is permitted to return all possible values for the Producer because the Wire object must remove all `Envelope` objects that have a scope name not listed in the Wire object's scope.

108.6.4 Composites and Flavors

Composite Producer and Consumer services must always use a flavor of the `Envelope` class. The data types of the values must be associated with the scope name or identification and mutually agreed between the Consumer and Producer services.

Flavors and `Envelope` objects both represent categories of different values. Flavors, however, are different Java classes that represent the same kind of value. For example, the tire pressure of the left front wheel could be passed as a `Float`, an `Integer`, or a `Measurement` object. Whatever data type is chosen, it is still the tire pressure of the left front wheel. The `Envelope` object represents the kind of object, for example the right front wheel tire pressure, or the left rear wheel.

108.6.5 Scope name syntax

Scope names are normal `String` objects and can, in principle, contain any Unicode character. Scope names are used with the `WirePermission` class that extends `java.security.BasicPermission`. The `BasicPermission` class implements the `implies` method and performs the name matching. The wildcard matching of this class is based on the concept of names where the constituents of the name are separated with a period ('.'): for example, `org.osgi.service.http.port`.

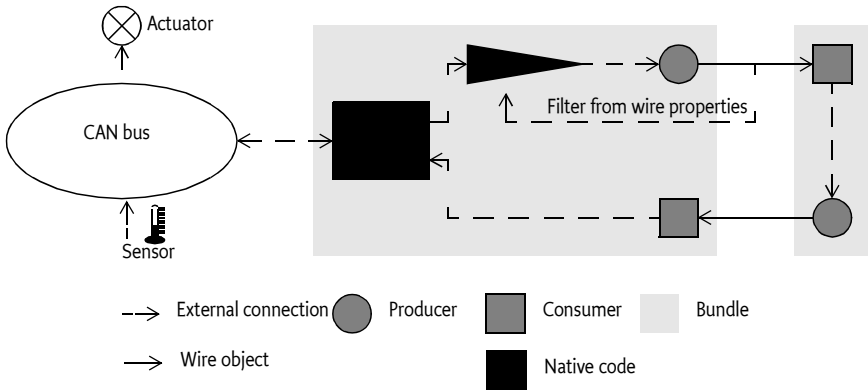
Scope names must therefore follow the rules for fully qualified Java class names. For example, `door.lock` is a correct scope name while `door-lock` is not.

108.7 Wire Flow Control

The `WIREADMIN_FILTER` property contains a filter expression (as defined in the `OSGi Framework Filter` class) that is used to limit the number of updates to the Consumer service. This is necessary because information can arrive at a much greater rate than can be processed by a Consumer service. For example, a single CAN bus (the electronic control bus used in current cars) in a car can easily deliver hundreds of measurements per second to an OSGi based controller. Most of these measurements are not relevant to the OSGi bundles, at least not all the time. For example, a bundle that maintains an indicator for the presence of frost is only interested in measurements when the outside temperature passes the 4 degrees Celsius mark.

Limiting the number of updates from a Producer service can make a significant difference in performance (meaning that less hardware is needed). For example, a vendor can implement the filter in native code and remove unnecessary updates prior to processing in the Java Virtual Machine (JVM). This is depicted in Figure 30 on page 166.

Figure 30 Filtering of Updates



The filter can use any combination of the following attributes in a filter to implement many common filtering schemes:

Table 16 Filter Attribute Names

Constant	Description
WIREVALUE_CURRENT	Current value of the data from the Producer service.
WIREVALUE_PREVIOUS	Previous data value that was reported to the Consumer service.
WIREVALUE_DELTA_ABSOLUTE	The actual positive difference between the previous data value and the current data value. For example, if the previous data value was 3 and the current data value is -0.5, then the absolute delta is 3.5. This filter attribute is not set when the current or previous value is not a number.
WIREVALUE_DELTA_RELATIVE	The absolute (meaning always positive) relative change between the current and the previous data values, calculated with the following formula: $ \text{previous} - \text{current} / \text{current} $. For example, if the previous value was 3 and the new value is 5, then the relative delta is $ 3 - 5 / 5 = 0.4$. This filter attribute is not set when the current or previous value is not a number.
WIREVALUE_ELAPSED	The time in milliseconds between the last time the Consumer <code>updated(Wire, Object)</code> returned and the time the filter is evaluated.

Filter attributes can be used to implement many common filtering schemes that limit the number of updates that are sent to a Consumer service. The Wire Admin service specification requires that updates to a Consumer service are always filtered if the `WIREADMIN_FILTER` Wire property is present. Producer services that wish to perform the filtering themselves should register with a service property `WIREADMIN_PRODUCER_FILTERS`. Filtering must be performed by the Wire object for all other Producer services.

Filtering for composite Producer services is not supported. When a filter is set on a Wire object, the Wire must still perform the filtering (which is limited to time filtering because an Envelope object is not a magnitude), but this approach may lose relevant information because the objects are of a different kind. For example, an update of every 500 ms could miss all speed updates because there is a wheel pressure update that resets the elapsed time. Producer services should, however, still implement a filtering scheme that could use proprietary attributes to filter on different kind of objects.

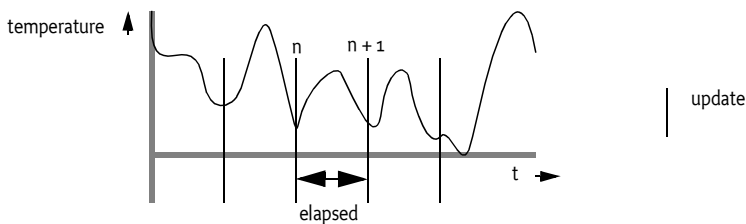
108.7.1 Filtering by Time

The simplest filter mechanism is based on time. The `wirevalue.elapsed` attribute contains the amount of milliseconds that have passed since the last update to the associated Consumer service. The following example filter expression illustrates how the updates can be limited to approximately 40 times per minute (once every 1500 ms).

```
(wirevalue.elapsed>=1500)
```

Figure 31 depicts this example graphically.

Figure 31 *Elapsed Time Change*



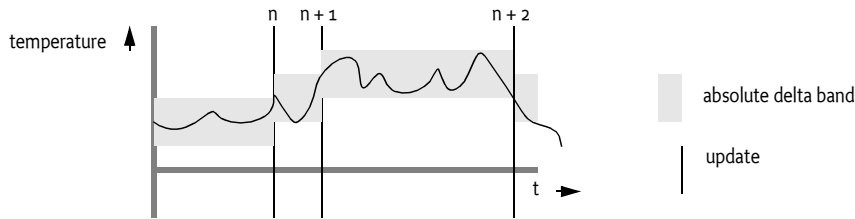
108.7.2 Filtering by Change

A Consumer service is often not interested in an update if the data value has not changed. The following filter expression shows how a Consumer service can limit the updates from a temperature sensor to be sent only when the temperature has changed at least 1 °K.

```
(wirevalue.delta.absolute>=1)
```

Figure 32 depicts a band that is created by the absolute delta between the previous data value and the current data value. The Consumer is only notified with the `updated(Wire, Object)` method when a data value is outside of this band.

Figure 32 Absolute Delta

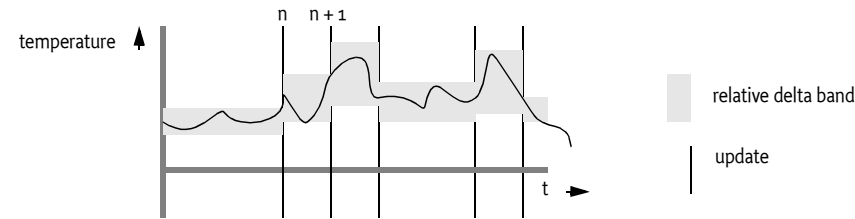


The delta may also be relative. For example, if a car is moving slowly, then updates of the speed of the car are interesting even for small variations. When a car is moving at a high rate of speed, updates are only interesting for larger variations in speed. The following example shows how the updates can be limited to data value changes of at least 10%.

```
(wirevalue.delta.relative>=0.1)
```

Figure 33 on page 168 depicts a relative band. Notice that the size of the band is directly proportional to the size of the sample value.

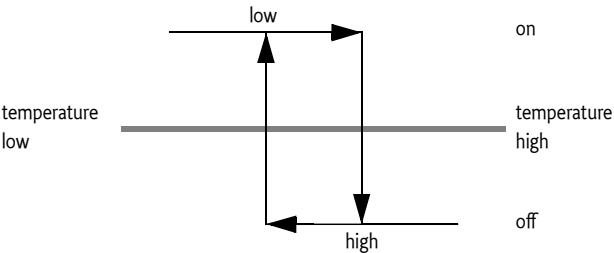
Figure 33 Relative Delta (not on scale)



108.7.3 Hysteresis

A thermostat is a control device that usually has a hysteresis, which means that a heater should be switched on below a certain specified low temperature and should be switched off at a specified high temperature, where *high* > *low*. This is graphically depicted in Figure 34 on page 168. The specified acceptable temperatures reduce the amount of start/stops of the heater.

Figure 34 Hysteresis



A Consumer service that controls the heater is only interested in events at the top and bottom of the hysteresis. If the specified high value is 250 °K and the specified low value is 249 °K, the following filter illustrates this concept:

```
( | (&(wirevalue.previous<=250) (wirevalue.current>250))
  (&(wirevalue.previous>=249) (wirevalue.current<249))
)
```

108.8 Flavors

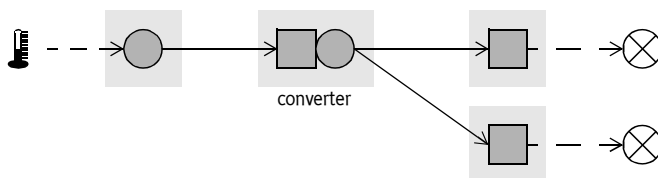
Both Consumer and Producer services should register with a property describing the classes of the data types they can consume or produce respectively. The classes are the *flavors* that the service supports. The purpose of flavors is to allow an administrative user interface bundle to connect Consumer and Producer services. Bundles should only create a connection when there is at least one class shared between the flavors from a Consumer service and a Producer service. Producer services are responsible for selecting the preferred object type from the list of the object types preferred by the Consumer service. If the Producer service cannot convert its data to any of the flavors listed by the Consumer service, null should be used instead.

108.9 Converters

A converter is a bundle that registers a Consumer and a Producer service that are related and performs data conversions. Data values delivered to the Consumer service are processed and transferred via the related Producer service. The Producer service sends the converted data to other Consumer services. This is shown in Figure 35.

Figure 35

Converter (for legend see Figure 27)



108.10 Wire Admin Service Implementation

The Wire Admin service is the administrative service that is used to control the wiring topology in the OSGi Service Platform. It contains methods to create or update wires, delete wires, and list existing wires. It is intended to be used by user interfaces or management programs that control the wiring topology of the OSGi Service Platform.

The `createWire(String,String,Dictionary)` method is used to associate a Producer service with a Consumer service. The method always creates and returns a new object. It is therefore possible to create multiple, distinct wires between a Producer and a Consumer service. The properties can be used to create multiple associations between Producer and Consumer services in that act in different ways.

The properties of a Wire object can be updated with the `update(Object)` method. This method must update the properties in the Wire object and must notify the associated Consumer and Producer services if they are registered. Wire objects that are no longer needed can be removed with the `deleteWire(Wire)` method. All these methods are in the WireAdmin class and not in the Wire class for security reasons. See *Security* on page 174.

The `getWires(String)` method returns an array of Wire objects (or null). All objects are returned when the filter argument is null. Specifying a filter argument limits the returned objects. The filter uses the same syntax as the Framework Filter specification. This filter is applied to the properties of the Wire object and only Wire objects that match this filter are returned.

The following example shows how the `getWires` method can be used to print the PIDs of Producer services that are wired to a specific Consumer service.

```
String f = "(wireadmin.consumer.pid=com.acme.x)";
Wire [] wires = getWireAdmin().getWires( f );
for ( int i=0; wires != null && i < wires.length; i++ )
    System.out.println(
        wires[i].getProperties().get(
            "wireadmin.producer.pid" )
    );
```

108.11 Wire Admin Listener Service Events

The Wire Admin service has an extensive list of events that it can deliver. The events allow other bundles to track changes in the topology as they happen. For example, a graphic user interface program can use the events to show when Wire objects become connected, when these objects are deleted, and when data flows over a Wire object.

A bundle that is interested in such events must register a WireAdminListener service object with a special Integer property WIREADMIN_EVENTS ("wireadmin.events"). This Integer object contains a bitmap of all the events in which this Wire Admin Listener service is interested (events have associated constants that can be OR'd together). A Wire Admin service must not deliver events to the Wire Admin Listener service when that event type is not in the bitmap. If no such property is registered, no events are delivered to the Wire Admin Listener service.

The WireAdminListener interface has only one method: `wireAdmin-Event(WireAdminEvent)`. The argument is a WireAdminEvent object that contains the event type and associated data.

A WireAdminEvent object can be sent asynchronously but must be ordered for each Wire Admin Listener service. Wire Admin Listener services must not assume that the state reflected by the event is still true when they receive the event.

The following types are defined for a WireEvent object:

Table 17 Events

Event type	Description
WIRE_CREATED	A new Wire object has been created.
WIRE_CONNECTED	Both the Producer service and the Consumer service are registered but may not have executed their respective connectedProducers/connectedConsumers methods.
WIRE_UPDATED	The Wire object's properties have been updated.
WIRE_TRACE	The Producer service has called the Wire.update(Object) method with a new value or the Producer service has returned from the Producer.pulled(Wire) method.
WIRE_DISCONNECTED	The Producer service or Consumer service have become unregistered and the Wire object is no longer connected.
WIRE_DELETED	The Wire object is deleted from the repository and is no longer available from the getWires method.
CONSUMER_EXCEPTION	The Consumer service generated an exception and the exception is included in the event.
PRODUCER_EXCEPTION	The Producer service generated an exception in a callback and the exception is included in the event.

108.11.1 Event Admin Service Events

Wire admin events must be sent asynchronously to the Event Admin service. The topic of a Wire Admin Event is one of the following:

org/osgi/service/wireadmin/WireAdminEvent/<event type>

The following event types are supported:

WIRE_CREATED
WIRE_CONNECTED
WIRE_UPDATED
WIRE_TRACE
WIRE_DISCONNECTED
WIRE_DELETED
PRODUCER_EXCEPTION
CONSUMER_EXCEPTION

The properties of a wire admin event are the following.

- event – (WireAdminEvent) The WireAdminEvent object broadcast by the Wire Admin service.

If the getWire method returns a non null value:

- wire – (Wire) The Wire object returned by the getWire method.
- wire.flavors – (String[]) The names of the classes returned by the Wire getFlavors method.

- `wire.scope` – (String[]) The scope of the Wire object, as returned by its `getScope` method.
- `wire.connected` – (Boolean) The result of the Wire `isConnected` method.
- `wire.valid` – (Boolean) The result of the Wire `isValid` method.

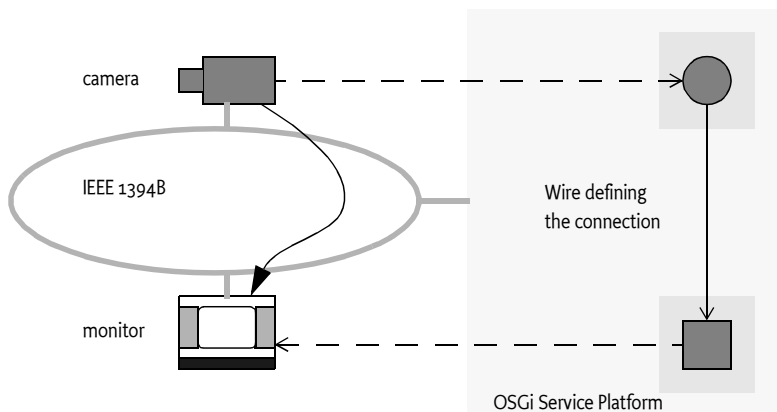
If the `getThrowable` method does not return null:

- `exception` – (Throwable) The Exception returned by the `getThrowable` method.
- `exception.class` – (String) The fully-qualified class name of the related Exception.
- `exception.message` – (String) The message of the related Exception
- `service` – (ServiceReference) The Service Reference of the Wire Admin service.
- `service.id` – (Long) The service id of the WireAdmin service.
- `service.objectClass` – (String[]) The Wire Admin service's object class (which must include `org.osgi.service.wireadmin.WireAdmin`)
- `service.pid` – (String) The Wire Admin service's PID.

108.12 Connecting External Entities

The Wire Admin service can be used to control the topology of consumers and producers that are services, as well as external entities. For example, a video camera controlled over an IEEE 1394B bus can be registered as a Producer service in the Framework's service registry and a TV, also connected to this bus, can be registered as a Consumer service. It would be very inefficient to stream the video data through the OSGi environment. Therefore, the Wire Admin service can be used to supply the external addressing information to the camera and the monitor to make a direct connection *outside* the OSGi environment. The Wire Admin service provides a uniform mechanism to connect both external entities and internal entities.

Figure 36 Connecting External Entities



A Consumer service and a Producer service associated with a Wire object receive enough information to establish a direct link because the PIDs of both services are in the Wire object's properties. This situation, however, does not guarantee *compatibility* between Producer and the Consumer ser-

vice. It is therefore recommended that flavors are used to ensure this compatibility. Producer services that participate in an external addressing scheme, like IEEE 1394B, should have a flavor that reflects this address. In this case, there should then for example be a IEEE 1394B address class. Consumer services that participate in this external addressing scheme should only accept data of this flavor.

The OSGi *Device Access Specification* on page 33, defines the concept of a device category. This is a description of what classes and properties are used in a specific device category: for example, a UPnP device category that defines the interface that must be used to register for a UPnP device, among other things.

Device category descriptions should include a section that addresses the external wiring issue. This section should include what objects are send over the wire to exchange addressing information.

108.13 Related Standards

108.13.1 Java Beans

The Wire Admin service leverages the component architecture that the Framework service registry offers. Java Beans attempt to achieve similar goals. Java Beans are classes that follow a number of recommendations that allow them to be configured at run time. The techniques that are used by Java Beans during configuration are serialization and the construction of adapter classes.

Creating adapter classes in a resource constrained OSGi Service Platform was considered too heavy weight. Also, the dynamic nature of the OSGi environment, where services are registered and unregistered continuously, creates a mismatch between the intended target area of Java Beans and the OSGi Service Platform.

Also, Java Beans can freely communicate once they have a reference to each other. This freedom makes it impossible to control the communication between Java Beans.

This Wire Admin service specification was developed because it is light-weight and leverages the unique characteristics of the OSGi Framework. The concept of a Wire object that acts as an intermediate between the Producer and Consumer service allows the implementation of a security policy because both parties cannot communicate directly.

108.14 Security

108.14.1 Separation of Consumer and Producer Services

The Consumer and Producer service never directly communicate with each other. All communication takes place through a `Wire` object. This allows a Wire Admin service implementation to control the security aspects of creating a connection, and implies that the Wire Admin service must be a trusted service in a secure environment. Only one bundle should have the `ServicePermission[WireAdmin, REGISTER]`.

`ServicePermission[Producer|Consumer, REGISTER]` should not be restricted. `ServicePermission[Producer|Consumer, GET]` must be limited to trusted bundles (the Wire Admin service implementation) because a bundle with this permission can call such services and access information that it should not be able to access.

108.14.2 Using Wire Admin Service

This specification assumes that only a few applications require access to the Wire Admin service. The `WireAdmin` interface contains all the security sensitive methods that create, update, and remove `Wire` objects. (This is the reason that the update and delete methods are on the `WireAdmin` interface and not on the `Wire` interface). `ServicePermission[WireAdmin, GET]` should therefore only be given to trusted bundles that can manage the topology.

108.14.3 Wire Permission

Composite Producer and Consumer services can be restricted in their use of scope names. This restriction is managed with the `WirePermission` class. A `WirePermission` consists of a scope name and the action `CONSUME` or `PRODUCE`. The name used with the `WirePermission` may contain wild-cards as specified in the `java.security.BasicPermission` class.

108.15 Changes

- Event Admin mapping added.

108.16 org.osgi.service.wireadmin

The OSGi Wire Admin service Package. Specification Version 1.0.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.service.wireadmin; version=1.0

108.16.1 Summary

- `BasicEnvelope` - `BasicEnvelope` is an implementation of the `Envelope`[p.176] interface [p.175]
- `Consumer` - `Data Consumer`, a service that can receive updated values from `Producer`[p.177] services. [p.175]

- Envelope - Identifies a contained value. [p.176]
- Producer - Data Producer, a service that can generate values to be used by Consumer[p.175] services. [p.177]
- Wire - A connection between a Producer service and a Consumer service. [p.179]
- WireAdmin - Wire Administration service. [p.182]
- WireAdminEvent - A Wire Admin Event. [p.184]
- WireAdminListener - Listener for Wire Admin Events. [p.187]
- WireConstants - Defines standard names for Wire properties, wire filter attributes, Consumer and Producer service properties. [p.188]
- WirePermission - Permission for the scope of a Wire object. [p.191]

108.16.2 **public class BasicEnvelope implements Envelope**

BasicEnvelope is an implementation of the Envelope[p.176] interface

108.16.2.1 **public BasicEnvelope(Object value, Object identification, String scope)**

value Content of this envelope, may be null.

identification Identifying object for this Envelope object, must not be null

scope Scope name for this object, must not be null

□ Constructor.

See Also Envelope[p.176]

108.16.2.2 **public Object getIdentification()**

See Also org.osgi.service.wireadmin.Envelope.getIdentification()[p.177]

108.16.2.3 **public String getScope()**

See Also org.osgi.service.wireadmin.Envelope.getScope()[p.177]

108.16.2.4 **public Object getValue()**

See Also org.osgi.service.wireadmin.Envelope.getValue()[p.177]

108.16.3 **public interface Consumer**

Data Consumer, a service that can receive updated values from Producer[p.177] services.

Service objects registered under the Consumer interface are expected to consume values from a Producer service via a Wire object. A Consumer service may poll the Producer service by calling the Wire.poll[p.181] method. The Consumer service will also receive an updated value when called at it's updated[p.176] method. The Producer service should have coerced the value to be an instance of one of the types specified by the Wire.getFlavors[p.179] method, or one of their subclasses.

Consumer service objects must register with a service.pid and a WireConstants.WIREADMIN_CONSUMER_FLAVORS[p.188] property. It is recommended that Consumer service objects also register with a service.description property.

If an Exception is thrown by any of the Consumer methods, a WireAdmin-Event of type WireAdminEvent.CONSUMER_EXCEPTION[p.185] is broadcast by the Wire Admin service.

Security Considerations - Data consuming bundles will require ServicePermission[Consumer,REGISTER]. In general, only the Wire Admin service bundle should have this permission. Thus only the Wire Admin service may directly call a Consumer service. Care must be taken in the sharing of Wire objects with other bundles.

Consumer services must be registered with their scope when they can receive different types of objects from the Producer service. The Consumer service should have WirePermission for each of these scope names.

108.16.3.1 **public void producersConnected(Wire[] wires)**

wires An array of the current and complete list of Wire objects to which this Consumer service is connected. May be null if the Consumer service is not currently connected to any Wire objects.

- Update the list of Wire objects to which this Consumer service is connected.

This method is called when the Consumer service is first registered and subsequently whenever a Wire associated with this Consumer service becomes connected, is modified or becomes disconnected.

The Wire Admin service must call this method asynchronously. This implies that implementors of Consumer can be assured that the callback will not take place during registration when they execute the registration in a synchronized method.

108.16.3.2 **public void updated(Wire wire, Object value)**

wire The Wire object which is delivering the updated value.

value The updated value. The value should be an instance of one of the types specified by the Wire.getFlavors[p.179] method.

- Update the value. This Consumer service is called by the Wire object with an updated value from the Producer service.

Note: This method may be called by a Wire object prior to this object being notified that it is connected to that Wire object (via the producersConnected[p.176] method).

When the Consumer service can receive Envelope objects, it must have registered all scope names together with the service object, and each of those names must be permitted by the bundle's WirePermission. If an Envelope object is delivered with the updated method, then the Consumer service should assume that the security check has been performed.

108.16.4 **public interface Envelope**

Identifies a contained value. An Envelope object combines a status value, an identification object and a scope name. The Envelope object allows the use of standard Java types when a Producer service can produce more than one kind of object. The Envelope object allows the Consumer service to recognize the kind of object that is received. For example, a door lock could be

represented by a Boolean object. If the Producer service would send such a Boolean object, then the Consumer service would not know what door the Boolean object represented. The Envelope object contains an identification object so the Consumer service can discriminate between different kinds of values. The identification object may be a simple String object, but it can also be a domain specific object that is mutually agreed by the Producer and the Consumer service. This object can then contain relevant information that makes the identification easier.

The scope name of the envelope is used for security. The Wire object must verify that any Envelope object send through the update method or coming from the poll method has a scope name that matches the permissions of both the Producer service and the Consumer service involved. The wireadmin package also contains a class BasicEnvelope that implements the methods of this interface.

See Also WirePermission[p.191], BasicEnvelope[p.175]

108.16.4.1 public Object getIdentification()

- ❑ Return the identification of this Envelope object. An identification may be of any Java type. The type must be mutually agreed between the Consumer and Producer services.

Returns an object which identifies the status item in the address space of the composite producer, must not be null.

108.16.4.2 public String getScope()

- ❑ Return the scope name of this Envelope object. Scope names are used to restrict the communication between the Producer and Consumer services. Only Envelopes objects with a scope name that is permitted for the Producer and the Consumer services must be passed through a Wire object.

Returns the security scope for the status item, must not be null.

108.16.4.3 public Object getValue()

- ❑ Return the value associated with this Envelope object.

Returns the value of the status item, or null when no item is associated with this object.

108.16.5 public interface Producer

Data Producer, a service that can generate values to be used by Consumer[p.175] services.

Service objects registered under the Producer interface are expected to produce values (internally generated or from external sensors). The value can be of different types. When delivering a value to a Wire object, the Producer service should coerce the value to be an instance of one of the types specified by Wire.getFlavors[p.179]. The classes are specified in order of preference.

When the data represented by the Producer object changes, this object should send the updated value by calling the update method on each of Wire objects passed in the most recent call to this object's consumersConnected[p.178] method. These Wire objects will pass the value on to the associated Consumer service object.

The Producer service may use the information in the Wire object's properties to schedule the delivery of values to the Wire object.

Producer service objects must register with a service.pid and a WireConstants.WIREADMIN_PRODUCER_FLAVORS[p.190] property. It is recommended that a Producer service object also registers with a service.description property. Producer service objects must register with a WireConstants.WIREADMIN_PRODUCER_FILTERS[p.190] property if the Producer service will be performing filtering instead of the Wire object.

If an exception is thrown by a Producer object method, a WireAdminEvent of type WireAdminEvent.PRODUCER_EXCEPTION[p.185] is broadcast by the Wire Admin service.

Security Considerations. Data producing bundles will require ServicePermission[Producer,REGISTER] to register a Producer service. In general, only the Wire Admin service should have ServicePermission[Producer,GET]. Thus only the Wire Admin service may directly call a Producer service. Care must be taken in the sharing of Wire objects with other bundles.

Producer services must be registered with scope names when they can send different types of objects (composite) to the Consumer service. The Producer service should have WirePermission for each of these scope names.

108.16.5.1 **public void consumersConnected(Wire[] wires)**

wires An array of the current and complete list of Wire objects to which this Producer service is connected. May be null if the Producer is not currently connected to any Wire objects.

- Update the list of Wire objects to which this Producer object is connected.

This method is called when the Producer service is first registered and subsequently whenever a Wire associated with this Producer becomes connected, is modified or becomes disconnected.

The Wire Admin service must call this method asynchronously. This implies that implementors of a Producer service can be assured that the call-back will not take place during registration when they execute the registration in a synchronized method.

108.16.5.2 **public Object polled(Wire wire)**

wire The Wire object which is polling this service.

- Return the current value of this Producer object.

This method is called by a Wire object in response to the Consumer service calling the Wire object's poll method. The Producer should coerce the value to be an instance of one of the types specified by Wire.getFlavors[p.179]. The types are specified in order of preference. The returned value should be as new or newer than the last value furnished by this object.

Note: This method may be called by a Wire object prior to this object being notified that it is connected to that Wire object (via the consumersConnected[p.178] method).

If the Producer service returns an Envelope object that has an unpermitted scope name, then the Wire object must ignore (or remove) the transfer.

If the Wire object has a scope set, the return value must be an array of Envelope objects (Envelope[]). The Wire object must have removed any Envelope objects that have a scope name that is not in the Wire object's scope.

Returns The current value of the Producer service or null if the value cannot be coerced into a compatible type. Or an array of Envelope objects.

108.16.6 **public interface Wire**

A connection between a Producer service and a Consumer service.

A Wire object connects a Producer service to a Consumer service. Both the Producer and Consumer services are identified by their unique service.pid values. The Producer and Consumer services may communicate with each other via Wire objects that connect them. The Producer service may send updated values to the Consumer service by calling the update[p.181] method. The Consumer service may request an updated value from the Producer service by calling the poll[p.181] method.

A Producer service and a Consumer service may be connected through multiple Wire objects.

Security Considerations. Wire objects are available to Producer and Consumer services connected to a given Wire object and to bundles which can access the WireAdmin service. A bundle must have ServicePermission[WireAdmin,GET] to get the WireAdmin service to access all Wire objects. A bundle registering a Producer service or a Consumer service must have the appropriate ServicePermission[ConsumerProducer,REGISTER] to register the service and will be passed Wire objects when the service object's consumersConnected or producersConnected method is called.

Scope. Each Wire object can have a scope set with the setScope method. This method should be called by a Consumer service when it assumes a Producer service that is composite (supports multiple information items). The names in the scope must be verified by the Wire object before it is used in communication. The semantics of the names depend on the Producer service and must not be interpreted by the Wire Admin service.

108.16.6.1 **public Class[] getFlavors()**

- Return the list of data types understood by the Consumer service connected to this Wire object. Note that subclasses of the classes in this list are acceptable data types as well.

The list is the value of the WireConstants.WIREADMIN_CONSUMER_FLAVORS[p.188] service property of the Consumer service object connected to this object. If no such property was registered or the type of the property value is not Class[], this method must return null.

Returns An array containing the list of classes understood by the Consumer service or null if the Wire is not connected, or the consumer did not register a WireConstants.WIREADMIN_CONSUMER_FLAVORS[p.188] property or the value of the property is not of type Class[].

108.16.6.2 **public Object getLastValue()**

- Return the last value sent through this Wire object.

The returned value is the most recent, valid value passed to the `update[p.181]` method or returned by the `poll[p.181]` method of this object. If filtering is performed by this Wire object, this methods returns the last value provided by the Producer service. This value may be an `Envelope[]` when the Producer service uses scoping. If the return value is an `Envelope` object (or array), it must be verified that the Consumer service has the proper `WirePermission` to see it.

Returns The last value passed though this Wire object or null if no valid values have been passed or the Consumer service has no permission.

108.16.6.3 **public Dictionary getProperties()**

- Return the wire properties for this Wire object.

Returns The properties for this Wire object. The returned Dictionary must be read only.

108.16.6.4 **public String[] getScope()**

- Return the calculated scope of this Wire object. The purpose of the Wire object's scope is to allow a Producer and/or Consumer service to produce/consume different types over a single Wire object (this was deemed necessary for efficiency reasons). Both the Consumer service and the Producer service must set an array of scope names (their scope) with the service registration property `WIREADMIN_PRODUCER_SCOPE`, or `WIREADMIN_CONSUMER_SCOPE` when they can produce multiple types. If a Producer service can produce different types, it should set this property to the array of scope names it can produce, the Consumer service must set the array of scope names it can consume. The scope of a Wire object is defined as the intersection of permitted scope names of the Producer service and Consumer service.

If neither the Consumer, or the Producer service registers scope names with its service registration, then the Wire object's scope must be null.

The Wire object's scope must not change when a Producer or Consumer services modifies its scope.

A scope name is permitted for a Producer service when the registering bundle has `WirePermission[name,PRODUCE]`, and for a Consumer service when the registering bundle has `WirePermission[name,CONSUME]`.

If either Consumer service or Producer service has not set a `WIREADMIN_*_SCOPE` property, then the returned value must be null.

If the scope is set, the Wire object must enforce the scope names when `Envelope` objects are used as a parameter to update or returned from the `poll` method. The Wire object must then remove all `Envelope` objects with a scope name that is not permitted.

Returns A list of permitted scope names or null if the Produce or Consumer service has set no scope names.

108.16.6.5 **public boolean hasScope(String name)**

name The scope name

- Return true if the given name is in this Wire object's scope.

Returns true if the name is listed in the permitted scope names

108.16.6.6 public boolean isConnected()

- Return the connection state of this Wire object.

A Wire is connected after the Wire Admin service receives notification that the Producer service and the Consumer service for this Wire object are both registered. This method will return true prior to notifying the Producer and Consumer services via calls to their respective `consumersConnected` and `producersConnected` methods.

A `WireAdminEvent` of type `WireAdminEvent.WIRE_CONNECTED`[p.185] must be broadcast by the Wire Admin service when the Wire becomes connected.

A Wire object is disconnected when either the Consumer or Producer service is unregistered or the Wire object is deleted.

A `WireAdminEvent` of type `WireAdminEvent.WIRE_DISCONNECTED`[p.185] must be broadcast by the Wire Admin service when the Wire becomes disconnected.

Returns true if both the Producer and Consumer for this Wire object are connected to the Wire object; false otherwise.

108.16.6.7 public boolean isValid()

- Return the state of this Wire object.

A connected Wire must always be disconnected before becoming invalid.

Returns false if this Wire object is invalid because it has been deleted via `WireAdmin.deleteWire`[p.183]; true otherwise.

108.16.6.8 public Object poll()

- Poll for an updated value.

This methods is normally called by the Consumer service to request an updated value from the Producer service connected to this Wire object. This Wire object will call the `Producer.poll`[p.178] method to obtain an updated value. If this Wire object is not connected, then the Producer service must not be called.

If this Wire object has a scope, then this method must return an array of `Envelope` objects. The objects returned must match the scope of this object. The Wire object must remove all `Envelope` objects with a scope name that is not in the Wire object's scope. Thus, the list of objects returned must only contain `Envelope` objects with a permitted scope name. If the array becomes empty, null must be returned.

A `WireAdminEvent` of type `WireAdminEvent.WIRE_TRACE`[p.186] must be broadcast by the Wire Admin service after the Producer service has been successfully called.

Returns A value whose type should be one of the types returned by `getFlavors`[p.179], `Envelope`[], or null if the Wire object is not connected, the Producer service threw an exception, or the Producer service returned a value which is not an instance of one of the types returned by `getFlavors`[p.179].

108.16.6.9 public void update(Object value)

value The updated value. The value should be an instance of one of the types returned by `getFlavors`[p.179].

- Update the value.

This methods is called by the Producer service to notify the Consumer service connected to this Wire object of an updated value.

If the properties of this Wire object contain a `WireConstants.WIREADMIN_FILTER`[p.189] property, then filtering is performed. If the Producer service connected to this Wire object was registered with the service property

`WireConstants.WIREADMIN_PRODUCER_FILTERS`[p.190], the Producer service will perform the filtering according to the rules specified for the filter. Otherwise, this Wire object will perform the filtering of the value.

If no filtering is done, or the filter indicates the updated value should be delivered to the Consumer service, then this Wire object must call the `Consumer.updated`[p.176] method with the updated value. If this Wire object is not connected, then the Consumer service must not be called and the value is ignored.

If the value is an Envelope object, and the scope name is not permitted, then the Wire object must ignore this call and not transfer the object to the Consumer service.

A `WireAdminEvent` of type `WireAdminEvent.WIRE_TRACE`[p.186] must be broadcast by the Wire Admin service after the Consumer service has been successfully called.

See Also `WireConstants.WIREADMIN_FILTER`[p.189]

108.16.7 public interface WireAdmin

Wire Administration service.

This service can be used to create Wire objects connecting a Producer service and a Consumer service. Wire objects also have wire properties that may be specified when a Wire object is created. The Producer and Consumer services may use the Wire object's properties to manage or control their interaction. The use of Wire object's properties by a Producer or Consumer services is optional.

Security Considerations. A bundle must have `ServicePermission[WireAdmin,GET]` to get the Wire Admin service to create, modify, find, and delete Wire objects.

108.16.7.1 public Wire createWire(String producerPID, String consumerPID, Dictionary properties)

producerPID The service.pid of the Producer service to be connected to the Wire object.

consumerPID The service.pid of the Consumer service to be connected to the Wire object.

properties The Wire object's properties. This argument may be null if the caller does not wish to define any Wire object's properties.

- ❑ Create a new Wire object that connects a Producer service to a Consumer service. The Producer service and Consumer service do not have to be registered when the Wire object is created.

The Wire configuration data must be persistently stored. All Wire connections are reestablished when the WireAdmin service is registered. A Wire can be permanently removed by using the `deleteWire`[p.183] method.

The Wire object's properties must have case insensitive String objects as keys (like the Framework). However, the case of the key must be preserved.

The WireAdmin service must automatically add the following Wire properties:

- `WireConstants.WIREADMIN_PID`[p.189] set to the value of the Wire object's persistent identity (PID). This value is generated by the Wire Admin service when a Wire object is created.
- `WireConstants.WIREADMIN_PRODUCER_PID`[p.190] set to the value of Producer service's PID.
- `WireConstants.WIREADMIN_CONSUMER_PID`[p.188] set to the value of Consumer service's PID.

If the properties argument already contains any of these keys, then the supplied values are replaced with the values assigned by the Wire Admin service.

The Wire Admin service must broadcast a `WireAdminEvent` of type `WireAdminEvent.WIRE_CREATED`[p.185] after the new Wire object becomes available from `getWires`[p.183].

Returns The Wire object for this connection.

Throws `IllegalArgumentException` – If properties contains invalid wire types or case variants of the same key name.

108.16.7.2 `public void deleteWire(Wire wire)`

wire The Wire object which is to be deleted.

- ❑ Delete a Wire object.

The Wire object representing a connection between a Producer service and a Consumer service must be removed. The persistently stored configuration data for the Wire object must be destroyed. The Wire object's method `Wire.isValid`[p.181] will return false after it is deleted.

The Wire Admin service must broadcast a `WireAdminEvent` of type `WireAdminEvent.WIRE_DELETED`[p.185] after the Wire object becomes invalid.

108.16.7.3 `public Wire[] getWires(String filter) throws InvalidSyntaxException`

filter Filter string to select Wire objects or null to select all Wire objects.

- ❑ Return the Wire objects that match the given filter.

The list of available Wire objects is matched against the specified filter. Wire objects which match the filter must be returned. These Wire objects are not necessarily connected. The Wire Admin service should not return invalid Wire objects, but it is possible that a Wire object is deleted after it was placed in the list.

The filter matches against the Wire object's properties including `WireConstants.WIREADMIN_PRODUCER_PID`[p.190], `WireConstants.WIREADMIN_CONSUMER_PID`[p.188] and `WireConstants.WIREADMIN_PID`[p.189].

Returns An array of Wire objects which match the filter or null if no Wire objects match the filter.

Throws `InvalidSyntaxException` – If the specified filter has an invalid syntax.

See Also `org.osgi.framework.Filter`

108.16.7.4 **public void updateWire(Wire wire, Dictionary properties)**

wire The Wire object which is to be updated.

properties The new Wire object's properties or null if no properties are required.

- Update the properties of a Wire object. The persistently stored configuration data for the Wire object is updated with the new properties and then the Consumer and Producer services will be called at the respective `Consumer.producersConnected`[p.176] and `Producer.consumersConnected`[p.178] methods.

The Wire Admin service must broadcast a `WireAdminEvent` of type `WireAdminEvent.WIRE_UPDATED`[p.186] after the updated properties are available from the Wire object.

Throws `IllegalArgumentException` – If properties contains invalid wire types or case variants of the same key name.

108.16.8 **public class WireAdminEvent**

A Wire Admin Event.

`WireAdminEvent` objects are delivered to all registered `WireAdminListener` service objects which specify an interest in the `WireAdminEvent` type. Events must be delivered in chronological order with respect to each listener. For example, a `WireAdminEvent` of type `WIRE_CONNECTED`[p.185] must be delivered before a `WireAdminEvent` of type `WIRE_DISCONNECTED`[p.185] for a particular Wire object.

A type code is used to identify the type of event. The following event types are defined:

- `WIRE_CREATED`[p.185]
- `WIRE_CONNECTED`[p.185]
- `WIRE_UPDATED`[p.186]
- `WIRE_TRACE`[p.186]
- `WIRE_DISCONNECTED`[p.185]
- `WIRE_DELETED`[p.185]
- `PRODUCER_EXCEPTION`[p.185]
- `CONSUMER_EXCEPTION`[p.185]

Event type values must be unique and disjoint bit values. Event types must be defined as a bit in a 32 bit integer and can thus be bitwise OR'ed together.

Security Considerations. `WireAdminEvent` objects contain Wire objects. Care must be taken in the sharing of Wire objects with other bundles.

See Also `WireAdminListener`[p.187]

108.16.8.1 public static final int CONSUMER_EXCEPTION = 2

A Consumer service method has thrown an exception.

This WireAdminEvent type indicates that a Consumer service method has thrown an exception. The WireAdminEvent.getThrowable[p.186] method will return the exception that the Consumer service method raised.

The value of CONSUMER_EXCEPTION is 0x00000002.

108.16.8.2 public static final int PRODUCER_EXCEPTION = 1

A Producer service method has thrown an exception.

This WireAdminEvent type indicates that a Producer service method has thrown an exception. The WireAdminEvent.getThrowable[p.186] method will return the exception that the Producer service method raised.

The value of PRODUCER_EXCEPTION is 0x00000001.

108.16.8.3 public static final int WIRE_CONNECTED = 32

The WireAdminEvent type that indicates that an existing Wire object has become connected. The Consumer object and the Producer object that are associated with the Wire object have both been registered and the Wire object is connected. See Wire.isConnected[p.181] for a description of the connected state. This event may come before the producersConnected and consumersConnected method have returned or called to allow synchronous delivery of the events. Both methods can cause other WireAdminEvent s to take place and requiring this event to be send before these methods are returned would mandate asynchronous delivery.

The value of WIRE_CONNECTED is 0x00000020.

108.16.8.4 public static final int WIRE_CREATED = 4

A Wire has been created.

This WireAdminEvent type that indicates that a new Wire object has been created. An event is broadcast when WireAdmin.createWire[p.182] is called. The WireAdminEvent.getWire[p.187] method will return the Wire object that has just been created.

The value of WIRE_CREATED is 0x00000004.

108.16.8.5 public static final int WIRE_DELETED = 16

A Wire has been deleted.

This WireAdminEvent type that indicates that an existing wire has been deleted. An event is broadcast when WireAdmin.deleteWire[p.183] is called with a valid wire. WireAdminEvent.getWire[p.187] will return the Wire object that has just been deleted.

The value of WIRE_DELETED is 0x00000010.

108.16.8.6 public static final int WIRE_DISCONNECTED = 64

The WireAdminEvent type that indicates that an existing Wire object has become disconnected. The Consumer object or/and Producer object is/are unregistered breaking the connection between the two. See Wire.isConnected[p.181] for a description of the connected state.

The value of WIRE_DISCONNECTED is 0x00000040.

108.16.8.7 public static final int WIRE_TRACE = 128

The WireAdminEvent type that indicates that a new value is transferred over the Wire object. This event is sent after the Consumer service has been notified by calling the Consumer.updated[p.176] method or the Consumer service requested a new value with the Wire.poll[p.181] method. This is an advisory event meaning that when this event is received, another update may already have occurred and this the Wire.getLastValue[p.179] method returns a newer value then the value that was communicated for this event.

The value of WIRE_TRACE is 0x00000080.

108.16.8.8 public static final int WIRE_UPDATED = 8

A Wire has been updated.

This WireAdminEvent type that indicates that an existing Wire object has been updated with new properties. An event is broadcast when WireAdmin.updateWire[p.184] is called with a valid wire. The WireAdminEvent.getWire[p.187] method will return the Wire object that has just been updated.

The value of WIRE_UPDATED is 0x00000008.

108.16.8.9 public WireAdminEvent(ServiceReference reference, int type, Wire wire, Throwable exception)

reference The ServiceReference object of the Wire Admin service that created this event.

type The event type. See getType[p.187].

wire The Wire object associated with this event.

exception An exception associated with this event. This may be null if no exception is associated with this event.

- Constructs a WireAdminEvent object from the given ServiceReference object, event type, Wire object and exception.

108.16.8.10 public ServiceReference getServiceReference()

- Return the ServiceReference object of the Wire Admin service that created this event.

Returns The ServiceReference object for the Wire Admin service that created this event.

108.16.8.11 public Throwable getThrowable()

- Returns the exception associated with the event, if any.

Returns An exception or null if no exception is associated with this event.

108.16.8.12 public int getType()

- Return the type of this event.

The type values are:

- WIRE_CREATED[p.185]
- WIRE_CONNECTED[p.185]
- WIRE_UPDATED[p.186]
- WIRE_TRACE[p.186]
- WIRE_DISCONNECTED[p.185]
- WIRE_DELETED[p.185]
- PRODUCER_EXCEPTION[p.185]
- CONSUMER_EXCEPTION[p.185]

Returns The type of this event.

108.16.8.13 public Wire getWire()

- Return the Wire object associated with this event.

Returns The Wire object associated with this event or null when no Wire object is associated with the event.

108.16.9 public interface WireAdminListener

Listener for Wire Admin Events.

WireAdminListener objects are registered with the Framework service registry and are notified with a WireAdminEvent object when an event is broadcast.

WireAdminListener objects can inspect the received WireAdminEvent object to determine its type, the Wire object with which it is associated, and the Wire Admin service that broadcasts the event.

WireAdminListener objects must be registered with a service property WireConstants.WIREADMIN_EVENTS[p.188] whose value is a bitwise OR of all the event types the listener is interested in receiving.

For example:

```
Integer mask = new Integer(WIRE_TRACE | WIRE_CONNECTED |
WIRE_DISCONNECTED);
Hashtable ht = new Hashtable();
ht.put(WIREADMIN_EVENTS, mask);
context.registerService(WireAdminListener.class.getName(),
this, ht);
```

If a WireAdminListener object is registered without a service property WireConstants.WIREADMIN_EVENTS[p.188], then the WireAdminListener will receive no events.

Security Considerations. Bundles wishing to monitor WireAdminEvent objects will require ServicePermission[WireAdminListener,REGISTER] to register a WireAdminListener service. Since WireAdminEvent objects contain Wire objects, care must be taken in assigning permission to register a WireAdminListener service.

See Also WireAdminEvent[p.184]

108.16.9.1 public void wireAdminEvent(WireAdminEvent event)

event The WireAdminEvent object.

- Receives notification of a broadcast WireAdminEvent object. The event object will be of an event type specified in this WireAdminListener service's WireConstants.WIREADMIN_EVENTS[p.188] service property.

108.16.10 public interface WireConstants

Defines standard names for Wire properties, wire filter attributes, Consumer and Producer service properties.

108.16.10.1 public static final String WIREADMIN_CONSUMER_COMPOSITE = "wireadmin.consumer.composite"

A service registration property for a Consumer service that is composite. It contains the names of the composite Producer services it can cooperate with. Inter-operability exists when any name in this array matches any name in the array set by the Producer service. The type of this property must be String[].

108.16.10.2 public static final String WIREADMIN_CONSUMER_FLAVORS = "wireadmin.consumer.flavors"

Service Registration property (named wireadmin.consumer.flavors) specifying the list of data types understood by this Consumer service.

The Consumer service object must be registered with this service property. The list must be in the order of preference with the first type being the most preferred. The value of the property must be of type Class[].

108.16.10.3 public static final String WIREADMIN_CONSUMER_PID = "wireadmin.consumer.pid"

Wire property key (named wireadmin.consumer.pid) specifying the service.pid of the associated Consumer service.

This wire property is automatically set by the Wire Admin service. The value of the property must be of type String.

108.16.10.4 public static final String WIREADMIN_CONSUMER_SCOPE = "wireadmin.consumer.scope"

Service registration property key (named wireadmin.consumer.scope) specifying a list of names that may be used to define the scope of this Wire object. A Consumer service should set this service property when it can produce more than one kind of value. This property is only used during registration, modifying the property must not have any effect of the Wire object's scope. Each name in the given list must have WirePermission[name, CONSUME] or else is ignored. The type of this service registration property must be String[].

See Also Wire.getScope[p.180], WIREADMIN_PRODUCER_SCOPE[p.190]

108.16.10.5 public static final String WIREADMIN_EVENTS = “wireadmin.events”

Service Registration property (named wireadmin.events) specifying the WireAdminEvent type of interest to a Wire Admin Listener service. The value of the property is a bitwise OR of all the WireAdminEvent types the Wire Admin Listener service wishes to receive and must be of type Integer.

See Also WireAdminEvent[p.184]

108.16.10.6 public static final String WIREADMIN_FILTER = “wireadmin.filter”

Wire property key (named wireadmin.filter) specifying a filter used to control the delivery rate of data between the Producer and the Consumer service.

This property should contain a filter as described in the Filter class. The filter can be used to specify when an updated value from the Producer service should be delivered to the Consumer service. In many cases the Consumer service does not need to receive the data with the same rate that the Producer service can generate data. This property can be used to control the delivery rate.

The filter can use a number of pre-defined attributes that can be used to control the delivery of new data values. If the filter produces a match upon the wire filter attributes, the Consumer service should be notified of the updated data value.

If the Producer service was registered with the WIREADMIN_PRODUCER_FILTERS[p.190] service property indicating that the Producer service will perform the data filtering then the Wire object will not perform data filtering. Otherwise, the Wire object must perform basic filtering. Basic filtering includes supporting the following standard wire filter attributes:

- WIREVALUE_CURRENT[p.190] - Current value
- WIREVALUE_PREVIOUS[p.191] - Previous value
- WIREVALUE_DELTA_ABSOLUTE[p.191] - Absolute delta
- WIREVALUE_DELTA_RELATIVE[p.191] - Relative delta
- WIREVALUE_ELAPSED[p.191] - Elapsed time

See Also org.osgi.framework.Filter

108.16.10.7 public static final String WIREADMIN_PID = “wireadmin.pid”

Wire property key (named wireadmin.pid) specifying the persistent identity (PID) of this Wire object.

Each Wire object has a PID to allow unique and persistent identification of a specific Wire object. The PID must be generated by the WireAdmin[p.182] service when the Wire object is created.

This wire property is automatically set by the Wire Admin service. The value of the property must be of type String.

108.16.10.8 public static final String WIREADMIN_PRODUCER_COMPOSITE =

“wireadmin.producer.composite”

A service registration property for a Producer service that is composite. It contains the names of the composite Consumer services it can inter-operate with. Inter-operability exists when any name in this array matches any name in the array set by the Consumer service. The type of this property must be `String[]`.

**108.16.10.9 public static final String WIREADMIN_PRODUCER_FILTERS =
“wireadmin.producer.filters”**

Service Registration property (named `wireadmin.producer.filters`). A Producer service registered with this property indicates to the Wire Admin service that the Producer service implements at least the filtering as described for the `WIREADMIN_FILTER`[p.189] property. If the Producer service is not registered with this property, the Wire object must perform the basic filtering as described in `WIREADMIN_FILTER`[p.189].

The type of the property value is not relevant. Only its presence is relevant.

**108.16.10.10 public static final String WIREADMIN_PRODUCER_FLAVORS =
“wireadmin.producer.flavors”**

Service Registration property (named `wireadmin.producer.flavors`) specifying the list of data types available from this Producer service.

The Producer service object should be registered with this service property.

The value of the property must be of type `Class[]`.

**108.16.10.11 public static final String WIREADMIN_PRODUCER_PID =
“wireadmin.producer.pid”**

Wire property key (named `wireadmin.producer.pid`) specifying the service.pid of the associated Producer service.

This wire property is automatically set by the WireAdmin service. The value of the property must be of type `String`.

**108.16.10.12 public static final String WIREADMIN_PRODUCER_SCOPE =
“wireadmin.producer.scope”**

Service registration property key (named `wireadmin.producer.scope`) specifying a list of names that may be used to define the scope of this Wire object. A Producer service should set this service property when it can produce more than one kind of value. This property is only used during registration, modifying the property must not have any effect of the Wire object's scope. Each name in the given list must have `WirePermission[name,PRODUCE]` or else is ignored. The type of this service registration property must be `String[]`.

See Also `Wire.getScope`[p.180], `WIREADMIN_CONSUMER_SCOPE`[p.188]

108.16.10.13 public static final String WIREADMIN_SCOPE_ALL

Matches all scope names.

- 108.16.10.14** **public static final String WIREVALUE_CURRENT = “wirevalue.current”**
Wire object’s filter attribute (named wirevalue.current) representing the current value.
- 108.16.10.15** **public static final String WIREVALUE_DELTA_ABSOLUTE = “wirevalue.delta.absolute”**
Wire object’s filter attribute (named wirevalue.delta.absolute) representing the absolute delta. The absolute (always positive) difference between the last update and the current value (only when numeric). This attribute must not be used when the values are not numeric.
- 108.16.10.16** **public static final String WIREVALUE_DELTA_RELATIVE = “wirevalue.delta.relative”**
Wire object’s filter attribute (named wirevalue.delta.relative) representing the relative delta. The relative difference is $|\text{previous} - \text{current}|$ (only when numeric). This attribute must not be used when the values are not numeric.
- 108.16.10.17** **public static final String WIREVALUE_ELAPSED = “wirevalue.elapsed”**
Wire object’s filter attribute (named wirevalue.elapsed) representing the elapsed time, in ms, between this filter evaluation and the last update of the Consumer service.
- 108.16.10.18** **public static final String WIREVALUE_PREVIOUS = “wirevalue.previous”**
Wire object’s filter attribute (named wirevalue.previous) representing the previous value.
- 108.16.11** **public final class WirePermission
extends BasicPermission**
Permission for the scope of a Wire object. When an Envelope object is used for communication with the poll or update method, and the scope is set, then the Wire object must verify that the Consumer service has WirePermission[name,CONSUME] and the Producer service has WirePermission[name,PRODUCE] for all names in the scope.

The names are compared with the normal rules for permission names. This means that they may end with a “*” to indicate wildcards. E.g. Door.* indicates all scope names starting with the string “Door”. The last period is required due to the implementations of the BasicPermission class.
- 108.16.11.1** **public static final String CONSUME = “consume”**
The action string for the CONSUME action: value is “consume”.
- 108.16.11.2** **public static final String PRODUCE = “produce”**
The action string for the PRODUCE action: value is “produce”.
- 108.16.11.3** **public WirePermission(String name, String actions)**
name Wire name.

actions produce, consume (canonical order).

- Create a new WirePermission with the given name (may be wildcard) and actions.

108.16.11.4 public boolean equals(Object obj)

obj The object to test for equality.

- Determines the equality of two WirePermission objects. Checks that specified object has the same name and actions as this WirePermission object.

Returns true if obj is a WirePermission, and has the same name and actions as this WirePermission object; false otherwise.

108.16.11.5 public String getActions()

- Returns the canonical string representation of the actions. Always returns present actions in the following order: produce, consume.

Returns The canonical string representation of the actions.

108.16.11.6 public int hashCode()

- Returns the hash code value for this object.

Returns Hash code value for this object.

108.16.11.7 public boolean implies(Permission p)

p The permission to check against.

- Checks if this WirePermission object implies the specified permission. More specifically, this method returns true if:
 - *p* is an instance of the WirePermission class,
 - *p*'s actions are a proper subset of this object's actions, and
 - *p*'s name is implied by this object's name. For example, java.* implies java.home.

Returns true if the specified permission is implied by this object; false otherwise.

108.16.11.8 public PermissionCollection newPermissionCollection()

- Returns a new PermissionCollection object for storing WirePermission objects.

Returns A new PermissionCollection object suitable for storing WirePermission objects.

108.16.11.9 public String toString()

- Returns a string describing this WirePermission. The convention is to specify the class name, the permission name, and the actions in the following format: '(org.osgi.service.wireadmin.WirePermission "name" "actions")'.

Returns information about this Permission object.

108.17 **References**

- [26] *Design Patterns*
Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides. Addison
Wesley, ISBN 0-201-63361

107 User Admin Service Specification

Version 1.1

107.1 Introduction

OSGi Service Platforms are often used in places where end users or devices initiate actions. These kinds of actions inevitably create a need for authenticating the initiator. Authenticating can be done in many different ways, including with passwords, one-time token cards, bio-metrics, and certificates.

Once the initiator is authenticated, it is necessary to verify that this principal is authorized to perform the requested action. This authorization can only be decided by the operator of the OSGi environment, and thus requires administration.

The User Admin service provides this type of functionality. Bundles can use the User Admin service to authenticate an initiator and represent this authentication as an `Authorization` object. Bundles that execute actions on behalf of this user can use the `Authorization` object to verify if that user is authorized.

The User Admin service provides authorization based on who runs the code, instead of using the Java code-based permission model. See [27] *The Java Security Architecture for JDK 1.2*. It performs a role similar to [28] *Java Authentication and Authorization Service*.

107.1.1 Essentials

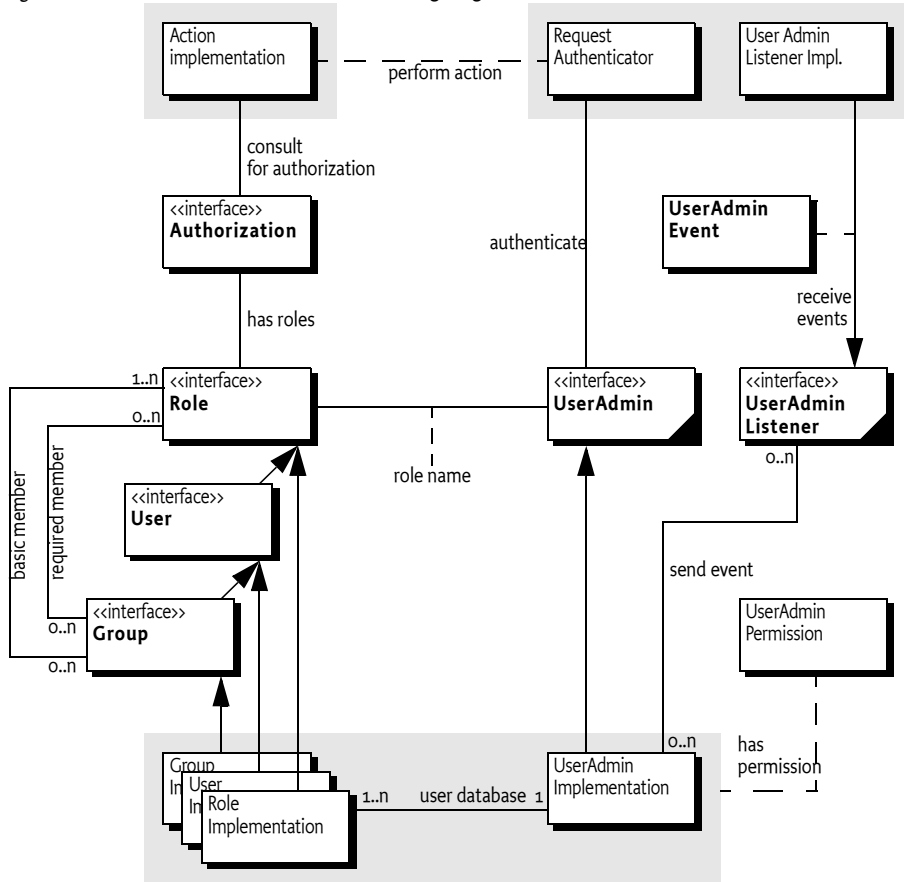
- *Authentication* – A large number of authentication schemes already exist, and more will be developed. The User Admin service must be flexible enough to adapt to the many different authentication schemes that can be run on a computer system.
- *Authorization* – All bundles should use the User Admin service to authenticate users and to find out if those users are authorized. It is therefore paramount that a bundle can find out authorization information with little effort.
- *Security* – Detailed security, based on the Framework security model, is needed to provide safe access to the User Admin service. It should allow limited access to the credentials and other properties.
- *Extensibility* – Other bundles should be able to build on the User Admin service. It should be possible to examine the information from this service and get real-time notifications of changes.
- *Properties* – The User Admin service must maintain a persistent database of users. It must be possible to use this database to hold more information about this user.

- *Administration* – Administering authorizations for each possible action and initiator is time-consuming and error-prone. It is therefore necessary to have mechanisms to group end users and make it simple to assign authorizations to all members of a group at one time.

107.1.2**Entities**

This Specification defines the following User Admin service entities:

- *UserAdmin* – This interface manages a database of named roles which can be used for authorization and authentication purposes.
- *Role* – This interface exposes the characteristics shared by all roles: a name, a type, and a set of properties.
- *User* – This interface (which extends *Role*) is used to represent any entity which may have credentials associated with it. These credentials can be used to authenticate an initiator.
- *Group* – This interface (which extends *User*) is used to contain an aggregation of named *Role* objects (*Group* or *User* objects).
- *Authorization* – This interface encapsulates an authorization context on which bundles can base authorization decisions.
- *UserAdminEvent* – This class is used to represent a role change event.
- *UserAdminListener* – This interface provides a listener for events of type *UserAdminEvent* that can be registered as a service.
- *UserAdminPermission* – This permission is needed to configure and access the roles managed by a User Admin service.
- *Role.USER_ANYONE* – This is a special *User* object that represents *any* user, it implies all other *User* objects. It is also used when a *Group* is used with only basic members. The *Role.USER_ANYONE* is then the only required member.

Figure 37 *User Admin Service, org.osgi.service.useradmin*

107.1.3 Operation

An Operator uses the User Admin service to define OSGi Service Platform users and configure them with properties, credentials, and *roles*.

A Role object represents the initiator of a request (human or otherwise). This specification defines two types of roles:

- *User* – A User object can be configured with credentials, such as a password, and properties, such as address, telephone number, and so on.
- *Group* – A Group object is an aggregation of *basic* and *required* roles. Basic and required roles are used in the authorization phase.

An OSGi Service Platform can have several entry points, each of which will be responsible for authenticating incoming requests. An example of an entry point is the Http Service, which delegates authentication of incoming requests to the `handleSecurity` method of the `HttpContext` object that was specified when the target servlet or resource of the request was registered.

The OSGi Service Platform entry points should use the information in the User Admin service to authenticate incoming requests, such as a password stored in the private credentials or the use of a certificate.

A bundle can determine if a request for an action is authorized by looking for a Role object that has the name of the requested action.

The bundle may execute the action if the Role object representing the initiator *implies* the Role object representing the requested action.

For example, an initiator Role object *X* implies an action Group object *A* if:

- *X* implies at least one of *A*'s basic members, and
- *X* implies all of *A*'s required members.

An initiator Role object *X* implies an action User object *A* if:

- *A* and *X* are equal.

The Authorization class handles this non-trivial logic. The User Admin service can capture the privileges of an authenticated User object into an Authorization object. The Authorization.hasRole method checks if the authenticate User object has (or implies) a specified action Role object.

For example, in the case of the Http Service, the HttpContext object can authenticate the initiator and place an Authorization object in the request header. The servlet calls the hasRole method on this Authorization object to verify that the initiator has the authority to perform a certain action. See *Authentication* on page 23.

107.2 Authentication

The authentication phase determines if the initiator is actually the one it says it is. Mechanisms to authenticate always need some information related to the user or the OSGi Service Platform to authenticate an external user. This information can consist of the following:

- A secret known only to the initiator.
- Knowledge about cards that can generate a unique token.
- Public information like certificates of trusted signers.
- Information about the user that can be measured in a trusted way.
- Other specific information.

107.2.1 Repository

The User Admin service offers a repository of Role objects. Each Role object has a unique name and a set of properties that are readable by anyone, and are changeable when the changer has the UserAdminPermission. Additionally, User objects, a sub-interface of Role, also have a set of private protected properties called credentials. Credentials are an extra set of properties that are used to authenticate users and that are protected by UserAdminPermission.

Properties are accessed with the Role.getProperties() method and credentials with the User.getCredentials() method. Both methods return a Dictionary object containing key/value pairs. The keys are String objects and the values of the Dictionary object are limited to String or byte[] objects.

This specification does not define any standard keys for the properties or credentials. The keys depend on the implementation of the authentication mechanism and are not formally defined by OSGi specifications.

The repository can be searched for objects that have a unique property (key/value pair) with the method `UserAdmin.getUser(String,String)`. This makes it easy to find a specific user related to a specific authentication mechanism. For example, a secure card mechanism that generates unique tokens could have a serial number identifying the user. The owner of the card could be found with the method

```
User owner = useradmin.getUser(
    "secure-card-serial", "132456712-1212" );
```

If multiple `User` objects have the same property (key *and* value), a null is returned.

There is a convenience method to verify that a user has a credential without actually getting the credential. This is the `User.hasCredential(String, Object)` method.

Access to credentials is protected on a name basis by `UserAdminPermission`. Because properties can be read by anyone with access to a `User` object, `UserAdminPermission` only protects change access to properties.

107.2.2

Basic Authentication

The following example shows a very simple authentication algorithm based on passwords.

The vendor of the authentication bundle uses the property "com.acme.basic-id" to contain the name of a user as it logs in. This property is used to locate the `User` object in the repository. Next, the credential "com.acme.password" contains the password and is compared to the entered password. If the password is correct, the `User` object is returned. In all other cases a `SecurityException` is thrown.

```
public User authenticate(
    UserAdmin ua, String name, String pwd )
    throws SecurityException {
    User user = ua.getUser("com.acme.basicid",
        username);
    if (user == null)
        throw new SecurityException( "No such user" );

    if (!user.hasCredential("com.acme.password", pwd))
        throw new SecurityException(
            "Invalid password" );
    return user;
}
```

107.2.3

Certificates

Authentication based on certificates does not require a shared secret. Instead, a certificate contains a name, a public key, and the signature of one or more signers.

The name in the certificate can be used to locate a User object in the repository. Locating a User object, however, only identifies the initiator and does not authenticate it.

1. The first step to authenticate the initiator is to verify that it has the private key of the certificate.
2. Next, the User Admin service must verify that it has a User object with the right property, for example "com.acme.certificate"="Fudd".
3. The next step is to see if the certificate is signed by a trusted source. The bundle could use a central list of trusted signers and only accept certificates signed by those sources. Alternatively, it could require that the certificate itself is already stored in the repository under a unique key as a byte[] in the credentials.
4. In any case, once the certificate is verified, the associated User object is authenticated.

107.3 Authorization

The User Admin service authorization architecture is a *role-based model*. In this model, every action that can be performed by a bundle is associated with a *role*. Such a role is a Group object (called group from now on) from the User Admin service repository. For example, if a servlet could be used to activate the alarm system, there should be a group named AlarmSystemActivation.

The operator can administrate authorizations by populating the group with User objects (users) and other groups. Groups are used to minimize the amount of administration required. For example, it is easier to create one Administrators group and add administrative roles to it rather than individually administer all users for each role. Such a group requires only one action to remove or add a user as an administrator.

The authorization decision can now be made in two fundamentally different ways:

An initiator could be allowed to carry out an action (represented by a Group object) if it implied any of the Group object's members. For example, the AlarmSystemActivation Group object contains an Administrators and a Family Group object:

```
Administrators      = { Elmer, Pepe, Bugs }
Family              = { Elmer, Pepe, Daffy }

AlarmSystemActivation = { Administrators, Family }
```

Any of the four members Elmer, Pepe, Daffy, or Bugs can activate the alarm system.

Alternatively, an initiator could be allowed to perform an action (represented by a Group object) if it implied *all* the Group object's members. In this case, using the same AlarmSystemActivation group, only Elmer and Pepe would be authorized to activate the alarm system, since Daffy and Bugs are *not* members of *both* the Administrators and Family Group objects.

The User Admin service supports a combination of both strategies by defining both a set of *basic members* (any) and a set of *required members* (all).

```
Administrators = { Elmer, Pepe, Bugs }
Family        = { Elmer, Pepe, Daffy }
```

```
AlarmSystemActivation
  required = { Administrators }
  basic    = { Family }
```

The difference is made when Role objects are added to the Group object. To add a basic member, use the Group.addMember(Role) method. To add a required member, use the Group.addRequiredMember(Role) method.

Basic members define the set of members that can get access and required members reduce this set by requiring the initiator to *imply* each required member.

A User object implies a Group object if it implies the following:

- All of the Group's required members, and
- At *least* one of the Group's basic members

A User object always implies itself.

If only required members are used to qualify the implication, then the standard user Role.[USER_ANYONE](#) can be obtained from the User Admin service and added to the Group object. This Role object is implied by anybody and therefore does not affect the required members.

107.3.1 The Authorization Object

The complexity of authorization is hidden in an Authorization class. Normally, the authenticator should retrieve an Authorization object from the User Admin service by passing the authenticated User object as an argument. This Authorization object is then passed to the bundle that performs the action. This bundle checks the authorization with the Authorization.hasRole(String) method. The performing bundle must pass the name of the action as an argument. The Authorization object checks whether the authenticated user implies the Role object, specifically a Group object, with the given name. This is shown in the following example.

```
public void activateAlarm(Authorization auth) {
    if ( auth.hasRole( "AlarmSystemActivation" ) ) {
        // activate the alarm
        ...
    }
    else throw new SecurityException(
        "Not authorized to activate alarm" );
}
```

107.3.2 Authorization Example

This section demonstrates a possible use of the User Admin service. The service has a flexible model and many other schemes are possible.

Assume an Operator installs an OSGi Service Platform. Bundles in this environment have defined the following action groups:

AlarmSystemControl
InternetAccess
TemperatureControl
PhotoAlbumEdit
PhotoAlbumView
PortForwarding

Installing and uninstalling bundles could potentially extend this set. Therefore, the Operator also defines a number of groups that can be used to contain the different types of system users.

Administrators
Buddies
Children
Adults
Residents

In a particular instance, the Operator installs it in a household with the following residents and buddies:

Residents: Elmer, Fudd, Marvin, Pepe
Buddies: Daffy, Foghorn

First, the residents and buddies are assigned to the system user groups. Second, the user groups need to be assigned to the action groups.

The following tables show how the groups could be assigned.

Table 18 Example Groups with Basic and Required Members

Groups	Elmer	Fudd	Marvin	Pepe	Daffy	Foghorn
Residents	Basic	Basic	Basic	Basic	-	-
Buddies	-	-	-	-	Basic	Basic
Children	-	-	Basic	Basic	-	-
Adults	Basic	Basic	-	-	-	-
Administrators	Basic	-	-	-	-	-

Table 19 Example Action Groups with their Basic and Required Members

Groups	Residents	Buddies	Children	Adults	Admin
AlarmSystemControl	Basic	-	-	-	Required
InternetAccess	Basic	-	-	Required	-
TemperatureControl	Basic	-	-	Required	-
PhotoAlbumEdit	Basic	-	Basic	Basic	-
PhotoAlbumView	Basic	Basic	-	-	-
PortForwarding	Basic	-	-	-	Required

107.4 Repository Maintenance

The UserAdmin interface is a straightforward API to maintain a repository of User and Group objects. It contains methods to create new Group and User objects with the `createRole(String,int)` method. The method is prepared so that the same signature can be used to create new types of roles in the future. The interface also contains a method to remove a Role object.

The existing configuration can be obtained with methods that list all Role objects using a filter argument. This filter, which has the same syntax as the Framework filter, must only return the Role objects for which the filter matches the properties.

Several utility methods simplify getting User objects depending on their properties.

107.5 User Admin Events

Changes in the User Admin service can be determined in real time. Each User Admin service implementation must send a `UserAdminEvent` object to any service in the Framework service registry that is registered under the `UserAdminListener` interface. This event must be send asynchronously from the cause of the event.

This procedure is demonstrated in the following code sample.

```
class Listener implements UserAdminListener {
    public void roleChanged( UserAdminEvent event ) {
        ...
    }
}

public class MyActivator
implements BundleActivator {
    public void start( BundleContext context ) {
        context.registerService(
            UserAdminListener.class.getName(),
            new Listener(), null );
    }
    public void stop( BundleContext context ) {}
}
```

It is not necessary to unregister the listener object when the bundle is stopped because the Framework automatically unregisters it. Once registered, the `UserAdminListener` object must be notified of all changes to the role repository.

107.5.1 Event Admin and User Admin Change Events

User admin events are delivered asynchronously to the Event Admin service. The topic of a User Admin Event is:

```
org.osgi/service/useradmin/UserAdmin/<event type>
```

The following event types are supported:

ROLE_CREATED
ROLE_CHANGED
ROLE_REMOVED

All User Admin Events must have the following properties:

- `event` – (`UserAdminEvent`) The event that was broadcast by the User Admin service.
- `role` – (`Role`) The Role object that was created, modified or removed.
- `role.name` – (`String`) The name of the role.
- `role.type` – (`Integer`) One of `ROLE`, `USER` or `GROUP`.
- `service` – (`ServiceReference`) The Service Reference of the User Admin service.
- `service.id` – (`Long`) The User Admin service's ID.
- `service.objectClass` – (`String[]`) The User Admin service's object class (which must include `org.osgi.service.useradmin.UserAdmin`)
- `service.pid` – (`String`) The User Admin service's persistent identity

107.6 Security

The User Admin service is related to the security model of the OSGi Service Platform, but is complementary to the [27] *The Java Security Architecture for JDK 1.2*. The final permission of most code should be the intersection of the Java 2 Permissions, which are based on the code that is executing, and the User Admin service authorization, which is based on the user for whom the code runs.

107.6.1 UserAdminPermission

The User Admin service defines the `UserAdminPermission` class that can be used to restrict bundles in accessing credentials. This permission class has the following actions:

- `changeProperty` – This permission is required to modify properties. The name of the permission is the prefix of the property name.
- `changeCredential` – This action permits changing credentials. The name of the permission is the prefix of the name of the credential.
- `getCredential` – This action permits getting credentials. The name of the permission is the prefix of the credential.

If the name of the permission is "admin", it allows the owner to administer the repository. No action is associated with the permission in that case.

Otherwise, the permission name is used to match the property name. This name may end with a "*" string to indicate a wildcard. For example, `com.acme.*` matches `com.acme.fudd.elmer` and `com.acme.bugs`.

107.7 Relation to JAAS

At a glance, the Java Authorization and Authentication Service (JAAS) seems to be a very suitable model for user administration. The OSGi organization, however, decided to develop an independent User Admin service because JAAS was not deemed applicable. The reasons for this include dependency on J2SE version 1.3 ("JDK 1.3") and existing mechanisms in the previous OSGi Service Gateway 1.0 specification.

107.7.1 JDK 1.3 Dependencies

The authorization component of JAAS relies on the `java.security.DomainCombiner` interface, which provides a means to dynamically update the `ProtectionDomain` objects affiliated with an `AccessContext` object.

This interface was added in JDK 1.3. In the context of JAAS, the `SubjectDomainCombiner` object, which implements the `DomainCombiner` interface, is used to update `ProtectionDomain` objects. The permissions of `ProtectionDomain` objects depend on where code came from and who signed it, with permissions based on who is running the code.

Leveraging JAAS would have resulted in user-based access control on the OSGi Service Platform being available only with JDK 1.3, which was not deemed acceptable.

107.7.2 Existing OSGi Mechanism

JAAS provides a pluggable authentication architecture, which enables applications and their underlying authentication services to remain independent from each other.

The `HttpService` already provides a similar feature by allowing servlet and resource registrations to be supported by an `HttpContext` object, which uses a callback mechanism to perform any required authentication checks before granting access to the servlet or resource. This way, the registering bundle has complete control on a per-servlet and per-resource basis over which authentication protocol to use, how the credentials presented by the remote requestor are to be validated, and who should be granted access to the servlet or resource.

107.7.3 Future Road Map

In the future, the main barrier of 1.3 compatibility will be removed. JAAS could then be implemented in an OSGi environment. At that time, the User Admin service will still be needed and will provide complementary services in the following ways:

- The authorization component relies on group membership information to be stored and managed outside JAAS. JAAS does not manage persistent information, so the User Admin service can be a provider of group information when principals are assigned to a `Subject` object.
- The authorization component allows for credentials to be collected and verified, but a repository is needed to actually validate the credentials.

In the future, the User Admin service can act as the back-end database to JAAS. The only aspect JAAS will remove from the User Admin service is the need for the Authorization interface.

107.8 Changes

- Role.USER_ANYONE string constant added.
- Event Admin mapping added.

107.9 org.osgi.service.useradmin

The OSGi User Admin service Package. Specification Version 1.1.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.service.useradmin; version=1.1

107.9.1 Summary

- Authorization - The Authorization interface encapsulates an authorization context on which bundles can base authorization decisions, where appropriate. [p.206]
- Group - A named grouping of roles (Role objects). [p.207]
- Role - The base interface for Role objects managed by the User Admin service. [p.209]
- User - A User role managed by a User Admin service. [p.210]
- UserAdmin - This interface is used to manage a database of named Role objects, which can be used for authentication and authorization purposes. [p.211]
- UserAdminEvent - Role change event. [p.213]
- UserAdminListener - Listener for UserAdminEvents. [p.214]
- UserAdminPermission - Permission to configure and access the Role[p.209] objects managed by a User Admin service. [p.215]

107.9.2 public interface Authorization

The Authorization interface encapsulates an authorization context on which bundles can base authorization decisions, where appropriate.

Bundles associate the privilege to access restricted resources or operations with roles. Before granting access to a restricted resource or operation, a bundle will check if the Authorization object passed to it possess the required role, by calling its hasRole method.

Authorization contexts are instantiated by calling the UserAdmin.getAuthorization[p.212] method.

Trusting Authorization objects

There are no restrictions regarding the creation of Authorization objects. Hence, a service must only accept Authorization objects from bundles that has been authorized to use the service using code based (or Java 2) permissions.

In some cases it is useful to use `ServicePermission` to do the code based access control. A service basing user access control on `Authorization` objects passed to it, will then require that a calling bundle has the `ServicePermission` to get the service in question. This is the most convenient way. The OSGi environment will do the code based permission check when the calling bundle attempts to get the service from the service registry.

Example: A servlet using a service on a user's behalf. The bundle with the servlet must be given the `ServicePermission` to get the `Http Service`.

However, in some cases the code based permission checks need to be more fine-grained. A service might allow all bundles to get it, but require certain code based permissions for some of its methods.

Example: A servlet using a service on a user's behalf, where some service functionality is open to anyone, and some is restricted by code based permissions. When a restricted method is called (e.g., one handing over an `Authorization` object), the service explicitly checks that the calling bundle has permission to make the call.

107.9.2.1 `public String getName()`

- Gets the name of the `User`[p.210] that this `Authorization` context was created for.

Returns The name of the `User`[p.210] object that this `Authorization` context was created for, or null if no user was specified when this `Authorization` context was created.

107.9.2.2 `public String[] getRoles()`

- Gets the names of all roles encapsulated by this `Authorization` context.

Returns The names of all roles encapsulated by this `Authorization` context, or null if no roles are in the context. The predefined role `user.anyone` will not be included in this list.

107.9.2.3 `public boolean hasRole(String name)`

name The name of the role to check for.

- Checks if the role with the specified name is implied by this `Authorization` context.

Bundles must define globally unique role names that are associated with the privilege of accessing restricted resources or operations. Operators will grant users access to these resources, by creating a `Group`[p.207] object for each role and adding `User`[p.210] objects to it.

Returns true if this `Authorization` context implies the specified role, otherwise false.

107.9.3 `public interface Group` `extends User`

A named grouping of roles (Role objects).

Whether or not a given `Authorization` context implies a `Group` object depends on the members of that `Group` object.

A Group object can have two kinds of members: *basic* and *required*. A Group object is implied by an Authorization context if all of its required members are implied and at least one of its basic members is implied.

A Group object must contain at least one basic member in order to be implied. In other words, a Group object without any basic member roles is never implied by any Authorization context.

A User object always implies itself.

No loop detection is performed when adding members to Group objects, which means that it is possible to create circular implications. Loop detection is instead done when roles are checked. The semantics is that if a role depends on itself (i.e., there is an implication loop), the role is not implied.

The rule that a Group object must have at least one basic member to be implied is motivated by the following example:

```
group foo
  required members: marketing
  basic members: alice, bob
```

Privileged operations that require membership in “foo” can be performed only by “alice” and “bob”, who are in marketing.

If “alice” and “bob” ever transfer to a different department, anybody in marketing will be able to assume the “foo” role, which certainly must be prevented. Requiring that “foo” (or any Group object for that matter) must have at least one basic member accomplishes that.

However, this would make it impossible for a Group object to be implied by just its required members. An example where this implication might be useful is the following declaration: “Any citizen who is an adult is allowed to vote.” An intuitive configuration of “voter” would be:

```
group voter
  required members: citizen, adult
  basic members:
```

However, according to the above rule, the “voter” role could never be assumed by anybody, since it lacks any basic members. In order to address this issue a predefined role named “user.anyone” can be specified, which is always implied. The desired implication of the “voter” group can then be achieved by specifying “user.anyone” as its basic member, as follows:

```
group voter
  required members: citizen, adult
  basic members: user.anyone
```

107.9.3.1 **public boolean addMember(Role role)**

role The role to add as a basic member.

- Adds the specified Role object as a basic member to this Group object.

Returns true if the given role could be added as a basic member, and false if this Group object already contains a Role object whose name matches that of the specified role.

Throws `SecurityException` – If a security manager exists and the caller does not have the `UserAdminPermission` with name `admin`.

107.9.3.2 `public boolean addRequiredMember(Role role)`

role The Role object to add as a required member.

- Adds the specified Role object as a required member to this Group object.

Returns true if the given Role object could be added as a required member, and false if this Group object already contains a Role object whose name matches that of the specified role.

Throws `SecurityException` – If a security manager exists and the caller does not have the `UserAdminPermission` with name `admin`.

107.9.3.3 `public Role[] getMembers()`

- Gets the basic members of this Group object.

Returns The basic members of this Group object, or null if this Group object does not contain any basic members.

107.9.3.4 `public Role[] getRequiredMembers()`

- Gets the required members of this Group object.

Returns The required members of this Group object, or null if this Group object does not contain any required members.

107.9.3.5 `public boolean removeMember(Role role)`

role The Role object to remove from this Group object.

- Removes the specified Role object from this Group object.

Returns true if the Role object could be removed, otherwise false.

Throws `SecurityException` – If a security manager exists and the caller does not have the `UserAdminPermission` with name `admin`.

107.9.4 `public interface Role`

The base interface for Role objects managed by the User Admin service.

This interface exposes the characteristics shared by all Role classes: a name, a type, and a set of properties.

Properties represent public information about the Role object that can be read by anyone. Specific `UserAdminPermission`[p.215] objects are required to change a Role object's properties.

Role object properties are Dictionary objects. Changes to these objects are propagated to the User Admin service and made persistent.

Every User Admin service contains a set of predefined Role objects that are always present and cannot be removed. All predefined Role objects are of type `ROLE`. This version of the `org.osgi.service.useradmin` package defines a single predefined role named “`user.anyone`”, which is inherited by any other role. Other predefined roles may be added in the future. Since “`user.anyone`”

is a Role object that has properties associated with it that can be read and modified. Access to these properties and their use is application specific and is controlled using `UserAdminPermission` in the same way that properties for other Role objects are.

107.9.4.1 `public static final int GROUP = 2`

The type of a Group[p.207] role.

The value of GROUP is 2.

107.9.4.2 `public static final int ROLE = 0`

The type of a predefined role.

The value of ROLE is 0.

107.9.4.3 `public static final int USER = 1`

The type of a User[p.210] role.

The value of USER is 1.

107.9.4.4 `public static final String USER_ANYONE = "user.anyone"`

The name of the predefined role, `user.anyone`, that all users and groups belong to.

Since 1.1

107.9.4.5 `public String getName()`

- Returns the name of this role.

Returns The role's name.

107.9.4.6 `public Dictionary getProperties()`

- Returns a Dictionary of the (public) properties of this Role object. Any changes to the returned Dictionary will change the properties of this Role object. This will cause a `UserAdminEvent` object of type `UserAdminEvent.ROLE_CHANGED`[p.213] to be broadcast to any `UserAdminListener` objects.

Only objects of type `String` may be used as property keys, and only objects of type `String` or `byte[]` may be used as property values. Any other types will cause an exception of type `IllegalArgumentException` to be raised.

In order to add, change, or remove a property in the returned Dictionary, a `UserAdminPermission`[p.215] named after the property name (or a prefix of it) with action `changeProperty` is required.

Returns Dictionary containing the properties of this Role object.

107.9.4.7 `public int getType()`

- Returns the type of this role.

Returns The role's type.

**107.9.5 public interface User
extends Role**

A User role managed by a User Admin service.

In this context, the term “user” is not limited to just human beings. Instead, it refers to any entity that may have any number of credentials associated with it that it may use to authenticate itself.

In general, User objects are associated with a specific User Admin service (namely the one that created them), and cannot be used with other User Admin services.

A User object may have credentials (and properties, inherited from the Role[p.209] class) associated with it. Specific UserAdminPermission[p.215] objects are required to read or change a User object’s credentials.

Credentials are Dictionary objects and have semantics that are similar to the properties in the Role class.

107.9.5.1 public Dictionary getCredentials()

- Returns a Dictionary of the credentials of this User object. Any changes to the returned Dictionary object will change the credentials of this User object. This will cause a UserAdminEvent object of type UserAdminEvent.ROLE_CHANGED[p.213] to be broadcast to any UserAdminListeners objects.

Only objects of type String may be used as credential keys, and only objects of type String or of type byte[] may be used as credential values. Any other types will cause an exception of type IllegalArgumentException to be raised.

In order to retrieve a credential from the returned Dictionary object, a UserAdminPermission[p.215] named after the credential name (or a prefix of it) with action getCredential is required.

In order to add or remove a credential from the returned Dictionary object, a UserAdminPermission[p.215] named after the credential name (or a prefix of it) with action changeCredential is required.

Returns Dictionary object containing the credentials of this User object.

107.9.5.2 public boolean hasCredential(String key, Object value)

key The credential key.

value The credential value.

- Checks to see if this User object has a credential with the specified key set to the specified value.

If the specified credential value is not of type String or byte[], it is ignored, that is, false is returned (as opposed to an IllegalArgumentException being raised).

Returns true if this user has the specified credential; false otherwise.

Throws SecurityException – If a security manager exists and the caller does not have the UserAdminPermission named after the credential key (or a prefix of it) with action getCredential.

107.9.6 public interface **UserAdmin**

This interface is used to manage a database of named Role objects, which can be used for authentication and authorization purposes.

This version of the User Admin service defines two types of Role objects: “User” and “Group”. Each type of role is represented by an int constant and an interface. The range of positive integers is reserved for new types of roles that may be added in the future. When defining proprietary role types, negative constant values must be used.

Every role has a name and a type.

A User[p.210] object can be configured with credentials (e.g., a password) and properties (e.g., a street address, phone number, etc.).

A Group[p.207] object represents an aggregation of User[p.210] and Group[p.207] objects. In other words, the members of a Group object are roles themselves.

Every User Admin service manages and maintains its own namespace of Role objects, in which each Role object has a unique name.

107.9.6.1 public Role **createRole(String name, int type)**

name The name of the Role object to create.

type The type of the Role object to create. Must be either a Role.USER[p.210] type or Role.GROUP[p.210] type.

- Creates a Role object with the given name and of the given type.

If a Role object was created, a UserAdminEvent object of type UserAdminEvent.ROLE_CREATED[p.214] is broadcast to any UserAdminListener object.

Returns The newly created Role object, or null if a role with the given name already exists.

Throws IllegalArgumentException – if type is invalid.

SecurityException – If a security manager exists and the caller does not have the UserAdminPermission with name admin.

107.9.6.2 public Authorization **getAuthorization(User user)**

user The User object to create an Authorization object for, or null for the anonymous user.

- Creates an Authorization object that encapsulates the specified User object and the Role objects it possesses. The null user is interpreted as the anonymous user. The anonymous user represents a user that has not been authenticated. An Authorization object for an anonymous user will be unnamed, and will only imply groups that user.anyone implies.

Returns the Authorization object for the specified User object.

107.9.6.3 public Role **getRole(String name)**

name The name of the Role object to get.

- Gets the Role object with the given name from this User Admin service.

Returns The requested Role object, or null if this User Admin service does not have a Role object with the given name.

107.9.6.4 `public Role[] getRoles(String filter) throws InvalidSyntaxException`

filter The filter criteria to match.

- Gets the Role objects managed by this User Admin service that have properties matching the specified LDAP filter criteria. See `org.osgi.framework.Filter` for a description of the filter syntax. If a null filter is specified, all Role objects managed by this User Admin service are returned.

Returns The Role objects managed by this User Admin service whose properties match the specified filter criteria, or all Role objects if a null filter is specified. If no roles match the filter, null will be returned.

Throws `InvalidSyntaxException` – If the filter is not well formed.

107.9.6.5 `public User getUser(String key, String value)`

key The property key to look for.

value The property value to compare with.

- Gets the user with the given property key-value pair from the User Admin service database. This is a convenience method for retrieving a User object based on a property for which every User object is supposed to have a unique value (within the scope of this User Admin service), such as for example a X.500 distinguished name.

Returns A matching user, if exactly one is found. If zero or more than one matching users are found, null is returned.

107.9.6.6 `public boolean removeRole(String name)`

name The name of the Role object to remove.

- Removes the Role object with the given name from this User Admin service. If the Role object was removed, a `UserAdminEvent` object of type `UserAdminEvent.ROLE_REMOVED`[p.214] is broadcast to any `UserAdminListener` object.

Returns true If a Role object with the given name is present in this User Admin service and could be removed, otherwise false.

Throws `SecurityException` – If a security manager exists and the caller does not have the `UserAdminPermission` with name `admin`.

107.9.7 `public class UserAdminEvent`

Role change event.

`UserAdminEvent` objects are delivered asynchronously to any `UserAdminListener` objects when a change occurs in any of the Role objects managed by a User Admin service.

A type code is used to identify the event. The following event types are defined: `ROLE_CREATED`[p.214] type, `ROLE_CHANGED`[p.213] type, and `ROLE_REMOVED`[p.214] type. Additional event types may be defined in the future.

See Also `UserAdmin`[p.211], `UserAdminListener`[p.214]

-
- 107.9.7.1** **public static final int ROLE_CHANGED = 2**
 A Role object has been modified.
 The value of ROLE_CHANGED is 0x00000002.
- 107.9.7.2** **public static final int ROLE_CREATED = 1**
 A Role object has been created.
 The value of ROLE_CREATED is 0x00000001.
- 107.9.7.3** **public static final int ROLE_REMOVED = 4**
 A Role object has been removed.
 The value of ROLE_REMOVED is 0x00000004.
- 107.9.7.4** **public UserAdminEvent(ServiceReference ref, int type, Role role)**
ref The ServiceReference object of the User Admin service that generated this event.
type The event type.
role The Role object on which this event occurred.
 □ Constructs a UserAdminEvent object from the given ServiceReference object, event type, and Role object.
- 107.9.7.5** **public Role getRole()**
 □ Gets the Role object this event was generated for.
Returns The Role object this event was generated for.
- 107.9.7.6** **public ServiceReference getServiceReference()**
 □ Gets the ServiceReference object of the User Admin service that generated this event.
Returns The User Admin service's ServiceReference object.
- 107.9.7.7** **public int getType()**
 □ Returns the type of this event.
 The type values are ROLE_CREATED[p.214] type, ROLE_CHANGED[p.213] type, and ROLE_REMOVED[p.214] type.
Returns The event type.
- 107.9.8** **public interface UserAdminListener**
 Listener for UserAdminEvents.
 UserAdminListener objects are registered with the Framework service registry and notified with a UserAdminEvent object when a Role object has been created, removed, or modified.
 UserAdminListener objects can further inspect the received UserAdminEvent object to determine its type, the Role object it occurred on, and the User Admin service that generated it.
See Also UserAdmin[p.211], UserAdminEvent[p.213]
-

107.9.8.1 public void roleChanged(UserAdminEvent event)

- event* The UserAdminEvent object.
- ❑ Receives notification that a Role object has been created, removed, or modified.

107.9.9 public final class UserAdminPermission extends BasicPermission

Permission to configure and access the Role[p.209] objects managed by a User Admin service.

This class represents access to the Role objects managed by a User Admin service and their properties and credentials (in the case of User[p.210] objects).

The permission name is the name (or name prefix) of a property or credential. The naming convention follows the hierarchical property naming convention. Also, an asterisk may appear at the end of the name, following a “.”, or by itself, to signify a wildcard match. For example: “org.osgi.security.protocol.*” or “*” is valid, but “*protocol” or “a*b” are not valid.

The UserAdminPermission with the reserved name “admin” represents the permission required for creating and removing Role objects in the User Admin service, as well as adding and removing members in a Group object. This UserAdminPermission does not have any actions associated with it.

The actions to be granted are passed to the constructor in a string containing a list of one or more comma-separated keywords. The possible keywords are: changeProperty,changeCredential, and getCredential. Their meaning is defined as follows:

action	
changeProperty	Permission to change (i.e., add and remove)
with	Role object properties whose names start
	the name argument specified in the constructor.
changeCredential	Permission to change (i.e., add and remove)
constructor.	User object credentials whose names start
	with the name argument specified in the
constructor.	
getCredential	Permission to retrieve and check for the existence of User object credentials
whose names	
	start with the name argument specified in
the	
	constructor.

The action string is converted to lowercase before processing.

Following is a PermissionInfo style policy entry which grants a user administration bundle a number of UserAdminPermission object:

```
(org.osgi.service.useradmin.UserAdminPermission "admin")
(org.osgi.service.useradmin.UserAdminPermission "com.foo.*"
"changeProperty,getCredential,changeCredential")
(org.osgi.service.useradmin.UserAdminPermission "user.*",
"changeProperty,changeCredential")
```

The first permission statement grants the bundle the permission to perform any User Admin service operations of type “admin”, that is, create and remove roles and configure Group objects.

The second permission statement grants the bundle the permission to change any properties as well as get and change any credentials whose names start with com.foo..

The third permission statement grants the bundle the permission to change any properties and credentials whose names start with user.. This means that the bundle is allowed to change, but not retrieve any credentials with the given prefix.

The following policy entry empowers the Http Service bundle to perform user authentication:

```
grant codeBase "${jars}http.jar" {
    permission org.osgi.service.useradmin.UserAdminPermission
        "user.password", "getCredential";
};
```

The permission statement grants the Http Service bundle the permission to validate any password credentials (for authentication purposes), but the bundle is not allowed to change any properties or credentials.

107.9.9.1 public static final String ADMIN = “admin”

The permission name “admin”.

107.9.9.2 public static final String CHANGE_CREDENTIAL = “changeCredential”

The action string “changeCredential”.

107.9.9.3 public static final String CHANGE_PROPERTY = “changeProperty”

The action string “changeProperty”.

107.9.9.4 public static final String GET_CREDENTIAL = “getCredential”

The action string “getCredential”.

107.9.9.5 public UserAdminPermission(String name, String actions)

name the name of this UserAdminPermission

actions the action string.

- Creates a new UserAdminPermission with the specified name and actions. name is either the reserved string “admin” or the name of a credential or property, and actions contains a comma-separated list of the actions granted on the specified name. Valid actions are changeProperty,changeCredential, and getCredential.

Throws `IllegalArgumentException` – If name equals “admin” and actions are specified.

107.9.9.6 **public boolean equals(Object obj)**

obj the object to be compared for equality with this object.

- Checks two `UserAdminPermission` objects for equality. Checks that *obj* is a `UserAdminPermission`, and has the same name and actions as this object.

Returns true if *obj* is a `UserAdminPermission` object, and has the same name and actions as this `UserAdminPermission` object.

107.9.9.7 **public String getActions()**

- Returns the canonical string representation of the actions, separated by comma.

Returns the canonical string representation of the actions.

107.9.9.8 **public int hashCode()**

- Returns the hash code of this `UserAdminPermission` object.

107.9.9.9 **public boolean implies(Permission p)**

p the permission to check against.

- Checks if this `UserAdminPermission` object “implies” the specified permission.

More specifically, this method returns true if:

- *p* is an instance of `UserAdminPermission`,
- *p*’s actions are a proper subset of this object’s actions, and
- *p*’s name is implied by this object’s name. For example, “java.*” implies “java.home”.

Returns true if the specified permission is implied by this object; false otherwise.

107.9.9.10 **public PermissionCollection newPermissionCollection()**

- Returns a new `PermissionCollection` object for storing `UserAdminPermission` objects.

Returns a new `PermissionCollection` object suitable for storing `UserAdminPermission` objects.

107.9.9.11 **public String toString()**

- Returns a string describing this `UserAdminPermission` object. This string must be in `PermissionInfo` encoded format.

Returns The `PermissionInfo` encoded string for this `UserAdminPermission` object.

See Also `org.osgi.service.permissionadmin.PermissionInfo.getEncoded`

107.10 References

- [27] *The Java Security Architecture for JDK 1.2*
Version 1.0, Sun Microsystems, October 1998

- [28] *Java Authentication and Authorization Service*
<http://java.sun.com/products/jaas>

109 IO Connector Service Specification

Version 1.0

109.1 Introduction

Communication is at the heart of OSGi Service Platform functionality. Therefore, a flexible and extendable communication API is needed: one that can handle all the complications that arise out of the Reference Architecture. These obstacles could include different communication protocols based on different networks, firewalls, intermittent connectivity, and others.

Therefore, this IO Connector Service specification adopts the [29] *Java 2 Micro Edition* (J2ME) `javax.microedition.io` packages as a basic communications infrastructure. In J2ME, this API is also called the Connector framework. A key aspect of this framework is that the connection is configured by a single string, the URI.

In J2ME, the Connector framework can be extended by the vendor of the Virtual Machine, but cannot be extended at run-time by other code. Therefore, this specification defines a service that adopts the flexible model of the Connector framework, but allows bundles to extend the Connector Services into different communication domains.

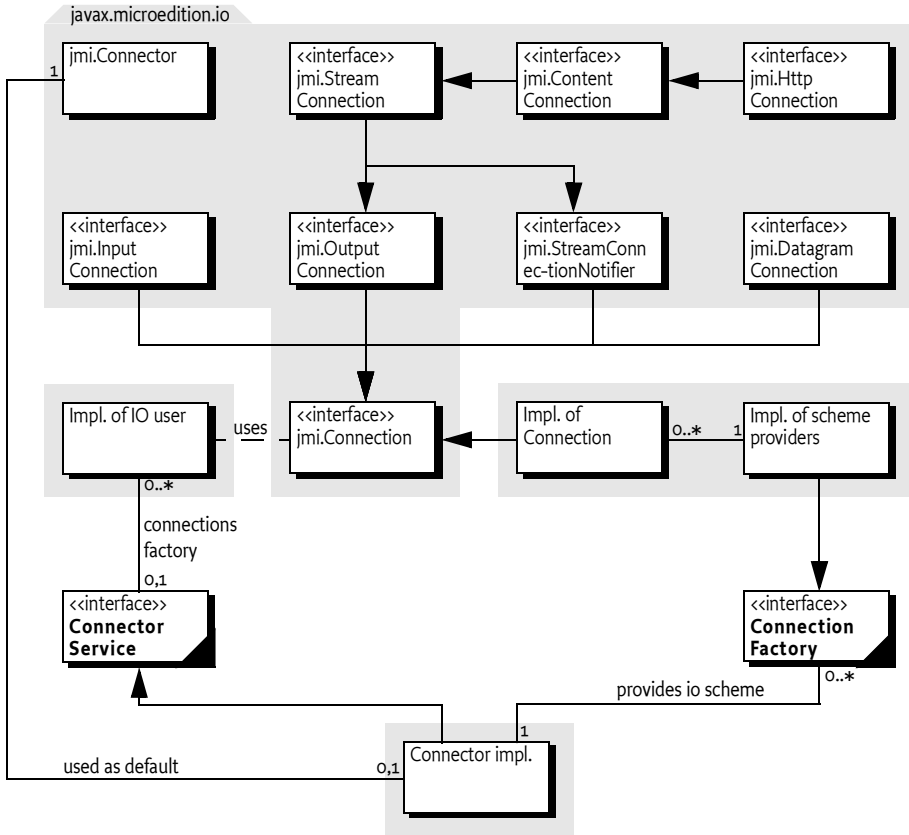
109.1.1 Essentials

- *Abstract* – Provide an intermediate layer that abstracts the actual protocol and devices from the bundle using it.
- *Extendable* – Allow third-party bundles to extend the system with new protocols and devices.
- *Layered* – Allow a protocol to be layered on top of lower layer protocols or devices.
- *Configurable* – Allow the selection of an actual protocol/device by means of configuration data.
- *Compatibility* – Be compatible with existing standards.

109.1.2 Entities

- *Connector Service* – The service that performs the same function—creating connections from different providers—as the static methods in the Connector framework of `javax.microedition.io`.
- *Connection Factory* – A service that extends the Connector service with more schemes.
- *Scheme* – A protocol or device that is supported in the Connector framework.

Figure 38 Class Diagram, *org.osgi.service.io* (*jmi* is *javax.microedition.io*)



109.2 The Connector Framework

The [29] *Java 2 Micro Edition* specification introduces a package for communicating with back-end systems. The requirements for this package are very similar to the following OSGi requirements:

- Small footprint
- Allows many different implementations simultaneously
- Simple to use
- Simple configuration

The key design goal of the Connector framework is to allow an application to use a communication mechanism/protocol without understanding implementation details.

An application passes a Uniform Resource Identifier (URI) to the `java.microedition.io.Connector` class, and receives an object implementing one or more `Connection` interfaces. The `java.microedition.io.Connector` class uses the scheme in the URI to locate the appropriate `ConnectionFactory` service. The remainder of the URI may contain parameters that are used by the `ConnectionFactory` service to establish the connection; for example, they may contain the baud rate for a serial connection. Some examples:

- sms://+46705950899;expiry=24h;reply=yes;type=9
- datagram://:53
- socket://www.acme.com:5302
- comm://COM1;baudrate=9600;databits=9
- file:c:/autoexec.bat

The `javax.microedition.io` API itself does not prescribe any schemes. It is up to the implementer of this package to include a number of extensions that provide the schemes. The `javax.microedition.io.Connector` class dispatches a request to a class which provides an implementation of a `Connection` interface. J2ME does not specify how this dispatching takes place, but implementations usually offer a proprietary mechanism to connect user defined classes that can provide new schemes.

The Connector framework defines a taxonomy of communication mechanisms with a number of interfaces. For example, a `javax.microedition.io.InputConnection` interface indicates that the connection supports the input stream semantics, such as an I/O port. A `javax.microedition.io.DatagramConnection` interface indicates that communication should take place with messages.

When a `javax.microedition.io.Connector.open` method is called, it returns a `javax.microedition.io.Connection` object. The interfaces implemented by this object define the type of the communication session. The following interfaces may be implemented:

- *HttpConnection* – A `javax.microedition.io.ContentConnection` with specific HTTP support.
- *DatagramConnection* – A connection that can be used to send and receive datagrams.
- *OutputConnection* – A connection that can be used for streaming output.
- *InputConnection* – A connection that can be used for streaming input.
- *StreamConnection* – A connection that is both input and output.
- *StreamConnectionNotifier* – Can be used to wait for incoming stream connection requests.
- *ContentConnection* – A `javax.microedition.io.StreamConnection` that provides information about the type, encoding, and length of the information.

Bundles using this approach must indicate to the Operator what kind of interfaces they expect to receive. The operator must then configure the bundle with a URI that contains the scheme and appropriate options that match the bundle's expectations. Well-written bundles are flexible enough to communicate with any of the types of `javax.microedition.io.Connection` interfaces they have specified. For example, a bundle should support `javax.microedition.io.StreamConnection` as well as `javax.microedition.io.DatagramConnection` objects in the appropriate direction (input or output).

The following code example shows a bundle that sends an alarm message with the help of the `javax.microedition.io.Connector` framework:

```
public class Alarm {
    String uri;
    public Alarm(String uri) { this.uri = uri; }
    private void send(byte[] msg) {
```

```

while ( true ) try {
    Connection connection = Connector.open( uri );
    DataOutputStream dout = null;
    if ( connection instanceof OutputConnection ) {
        dout = ((OutputConnection)
            connection).openDataOutputStream();
        dout.write( msg );
    }
    else if (connection instanceof DatagramConnection) {
        DatagramConnection dgc =
            (DatagramConnection) connection;
        Datagram datagram = dgc.newDatagram(
            msg, msg.length );
        dgc.send( datagram );
    } else {
        error( "No configuration for alarm" );
        return;
    }
    connection.close();
} catch( Exception e ) { ... }
}
}

```

109.3 Connector Service

The `javax.microedition.io.Connector` framework matches the requirements for OSGi applications very well. The actual creation of connections, however, is handled through static methods in the `javax.microedition.io.Connector` class. This approach does not mesh well with the OSGi service registry and dynamic life-cycle management.

This specification therefore introduces the Connector Service. The methods of the `ConnectorService` interface have the same signatures as the static methods of the `javax.microedition.io.Connector` class.

Each `javax.microedition.io.Connection` object returned by a Connector Service must implement interfaces from the `javax.microedition.io` package. Implementations must strictly follow the semantics that are associated with these interfaces.

The Connector Service must provide all the schemes provided by the exporter of the `javax.microedition.io` package. The Connection Factory services must have priority over schemes implemented in the Java run-time environment. For example, if a Connection Factory provides the http scheme and a built-in implementation exists, then the Connector Service must use the Connection Factory service with the http scheme.

Bundles that want to use the Connector Service should first obtain a `ConnectorService` service object. This object contains open methods that should be called to get a new `javax.microedition.io.Connection` object.

109.4 Providing New Schemes

The Connector Service must be able to be extended with the Connection Factory service. Bundles that can provide new schemes must register a ConnectionFactory service object.

The Connector Service must listen for registrations of new ConnectionFactory service objects and make the supplied schemes available to bundles that create connections.

Implementing a Connection Factory service requires implementing the following method:

- `createConnection(String,int,boolean)` – Creates a new connection object from the given URI.

The Connection Factory service must be registered with the `IO_SCHEME` property to indicate the provided scheme to the Connector Service. The value of this property must be a `String[]` object.

If multiple Connection Factory services register with the same scheme, the Connector Service should select the Connection Factory service with the highest value for the `service.ranking` service registration property, or if more than one Connection Factory service has the highest value, the Connection Factory service with the lowest `service.id` is selected.

The following example shows how a Connection Factory service may be implemented. The example will return a `javax.microedition.io.InputConnection` object that returns the value of the URI after removing the scheme identifier.

```
public class ConnectionFactoryImpl
    implements BundleActivator, ConnectionFactory {
    public void start( BundleContext context ) {
        Hashtable properties = new Hashtable();
        properties.put( IO_SCHEME,
            new String[] { "data" } );
        context.registerService(
            ConnectorService.class.getName(),
            this, properties );
    }
    public void stop( BundleContext context ) {}

    public Connection createConnection(
        String uri, int mode, boolean timeouts ) {
        return new DataConnection(uri);
    }
}

class DataConnection
    implements javax.microedition.io.InputConnection {
    String uri;
    DataConnection( String uri ) {this.uri = uri;}
    public DataInputStream openDataInputStream()
        throws IOException {
```

```
        return new DataInputStream( openInputStream() );
    }

    public InputStream openInputStream() throws IOException {
        byte [] buf = uri.getBytes();
        return new ByteArrayInputStream(buf, 5, buf.length-5);
    }
    public void close() {}
}
```

109.4.1 Orphaned Connection Objects

When a Connection Factory service is unregistered, it must close all Connection objects that are still open. Closing these Connection objects should make these objects unusable, and they should subsequently throw an IOException when used.

Bundles should not unnecessarily hang onto objects they retrieved from services. Implementations of Connection Factory services should program defensively and ensure that resource allocation is minimized when a Connection object is closed.

109.5 Execution Environment

The `javax.microedition.io` package is available in J2ME configurations/profiles, but is not present in J2SE, J2EE, and the OSGi minimum execution requirements.

Implementations of the Connector Service that are targeted for all environments should carry their own implementation of the `javax.microedition.io` package and export it.

109.6 Security

The OSGi Connector Service is a key service available in the Service Platform. A malicious bundle which provides this service can spoof any communication. Therefore, it is paramount that the `ServicePermission[ConnectorService, REGISTER]` is given only to a trusted bundle. `ServicePermission[ConnectorService, GET]` may be handed to bundles that are allowed to communicate to the external world.

`ServicePermission[ConnectionFactory, REGISTER]` should also be restricted to trusted bundles because they can implement specific protocols or access devices. `ServicePermission[ConnectionFactory, GET]` should be limited to trusted bundles that implement the Connector Service.

Implementations of Connection Factory services must perform all I/O operations within a privileged region. For example, an implementation of the `sms: scheme` must have permission to access the mobile phone, and should not require the bundle that opened the connection to have this permission. Normally, the operations need to be implemented in a `doPrivileged` method or in a separate thread.

If a specific Connection Factory service needs more detailed permissions than provided by the OSGi or Java 2, it may create a new specific Permission sub-class for its purpose.

109.7 org.osgi.service.io

The OSGi IO Connector Specification Version 1.0.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

```
Import-Package: org.osgi.service.io; version=1.0, javax.microedition.io
```

109.7.1 Summary

- **ConnectionFactory** - A Connection Factory service is called by the implementation of the Connector Service to create javax.microedition.io.Connection objects which implement the scheme named by IO_SCHEME. [p.223]
- **ConnectorService** - The Connector Service should be called to create and open javax.microedition.io.Connection objects. [p.225]

109.7.2 public interface ConnectionFactory

A Connection Factory service is called by the implementation of the Connector Service to create javax.microedition.io.Connection objects which implement the scheme named by IO_SCHEME. When a ConnectorService.open method is called, the implementation of the Connector Service will examine the specified name for a scheme. The Connector Service will then look for a Connection Factory service which is registered with the service property IO_SCHEME which matches the scheme. The createConnection[p.225] method of the selected Connection Factory will then be called to create the actual Connection object.

109.7.2.1 public static final String IO_SCHEME = "io.scheme"

Service property containing the scheme(s) for which this Connection Factory can create Connection objects. This property is of type String[].

109.7.2.2 public Connection createConnection(String name, int mode, boolean timeouts) throws IOException

name The full URI passed to the ConnectorService.open method

mode The mode parameter passed to the ConnectorService.open method

timeouts The timeouts parameter passed to the ConnectorService.open method

- Create a new Connection object for the specified URI.

Returns A new javax.microedition.io.Connection object.

Throws IOException – If a javax.microedition.io.Connection object can not be created.

109.7.3 public interface **ConnectorService**

The Connector Service should be called to create and open `javax.microedition.io.Connection` objects. When an `open*` method is called, the implementation of the Connector Service will examine the specified name for a scheme. The Connector Service will then look for a Connection Factory service which is registered with the service property `IO_SCHEME` which matches the scheme. The `createConnection` method of the selected Connection Factory will then be called to create the actual Connection object.

If more than one Connection Factory service is registered for a particular scheme, the service with the highest ranking (as specified in its `service.ranking` property) is called. If there is a tie in ranking, the service with the lowest service ID (as specified in its `service.id` property), that is the service that was registered first, is called. This is the same algorithm used by `BundleContext.getServiceReference`.

109.7.3.1 public static final int **READ = 1**

Read access mode.

See Also `javax.microedition.io.Connector.READ`

109.7.3.2 public static final int **READ_WRITE = 3**

Read/Write access mode.

See Also `javax.microedition.io.Connector.READ_WRITE`

109.7.3.3 public static final int **WRITE = 2**

Write access mode.

See Also `javax.microedition.io.Connector.WRITE`

109.7.3.4 public Connection **open(String name) throws IOException**

name The URI for the connection.

- Create and open a Connection object for the specified name.

Returns A new `javax.microedition.io.Connection` object.

Throws `IllegalArgumentException` – If a parameter is invalid.

`javax.microedition.io.ConnectionNotFoundException` – If the connection cannot be found.

`IOException` – If some other kind of I/O error occurs.

See Also `javax.microedition.io.Connector.open(String name)`

109.7.3.5 public Connection **open(String name, int mode) throws IOException**

name The URI for the connection.

mode The access mode.

- Create and open a Connection object for the specified name and access mode.

Returns A new `javax.microedition.io.Connection` object.

Throws `IllegalArgumentException` – If a parameter is invalid.

`javax.microedition.io.ConnectionNotFoundException` – If the connection cannot be found.

`IOException` – If some other kind of I/O error occurs.

See Also `javax.microedition.io.Connector.open(String name, int mode)`

109.7.3.6 **public Connection open(String name, int mode, boolean timeouts) throws IOException**

name The URI for the connection.

mode The access mode.

timeouts A flag to indicate that the caller wants timeout exceptions.

- Create and open a `Connection` object for the specified name, access mode and timeouts.

Returns A new `javax.microedition.io.Connection` object.

Throws `IllegalArgumentException` – If a parameter is invalid.

`javax.microedition.io.ConnectionNotFoundException` – If the connection cannot be found.

`IOException` – If some other kind of I/O error occurs.

See Also `javax.microedition.io.Connector.open`

109.7.3.7 **public DataInputStream openDataInputStream(String name) throws IOException**

name The URI for the connection.

- Create and open a `DataInputStream` object for the specified name.

Returns A `DataInputStream` object.

Throws `IllegalArgumentException` – If a parameter is invalid.

`javax.microedition.io.ConnectionNotFoundException` – If the connection cannot be found.

`IOException` – If some other kind of I/O error occurs.

See Also `javax.microedition.io.Connector.openDataInputStream(String name)`

109.7.3.8 **public DataOutputStream openDataOutputStream(String name) throws IOException**

name The URI for the connection.

- Create and open a `DataOutputStream` object for the specified name.

Returns A `DataOutputStream` object.

Throws `IllegalArgumentException` – If a parameter is invalid.

`javax.microedition.io.ConnectionNotFoundException` – If the connection cannot be found.

`IOException` – If some other kind of I/O error occurs.

See Also `javax.microedition.io.Connector.openDataOutputStream(String name)`

109.7.3.9 public InputStream openInputStream(String name) throws IOException

name The URI for the connection.

- Create and open an InputStream object for the specified name.

Returns An InputStream object.

Throws IllegalArgumentException – If a parameter is invalid.

javax.microedition.io.ConnectionNotFoundException – If the connection cannot be found.

IOException – If some other kind of I/O error occurs.

See Also javax.microedition.io.Connector.openInputStream(String name)

109.7.3.10 public OutputStream openOutputStream(String name) throws IOException

name The URI for the connection.

- Create and open an OutputStream object for the specified name.

Returns An OutputStream object.

Throws IllegalArgumentException – If a parameter is invalid.

javax.microedition.io.ConnectionNotFoundException – If the connection cannot be found.

IOException – If some other kind of I/O error occurs.

See Also javax.microedition.io.Connector.openOutputStream(String name)

109.8 References

- [29] *Java 2 Micro Edition*
<http://java.sun.com/j2me/>
- [30] *javax.microedition.io whitepaper*
<http://wireless.java.sun.com/midp/chapters/j2mewhite/chap13.pdf>
- [31] *J2ME Foundation Profile*
<http://www.jcp.org/jsr/detail/46.jsp>

110 Initial Provisioning

Version 1.1

110.1 Introduction

To allow freedom regarding the choice of management protocol, the OSGi Specifications assumes an architecture to remotely manage a Service Platform with a Management Agent. The Management Agent is implemented with a Management Bundle that can communicate with an unspecified management protocol.

This specification defines how the Management Agent can make its way to the Service Platform, and gives a structured view of the problems and their corresponding resolution methods.

The purpose of this specification is to enable the management of a Service Platform by an Operator, and (optionally) to hand over the management of the Service Platform later to another Operator. This approach is in accordance with the OSGi remote management reference architecture.

This bootstrapping process requires the installation of a Management Agent, with appropriate configuration data, in the Service Platform.

This specification consists of a prologue, in which the principles of the Initial Provisioning are outlined, and a number of mappings to different mechanisms.

110.1.1 Essentials

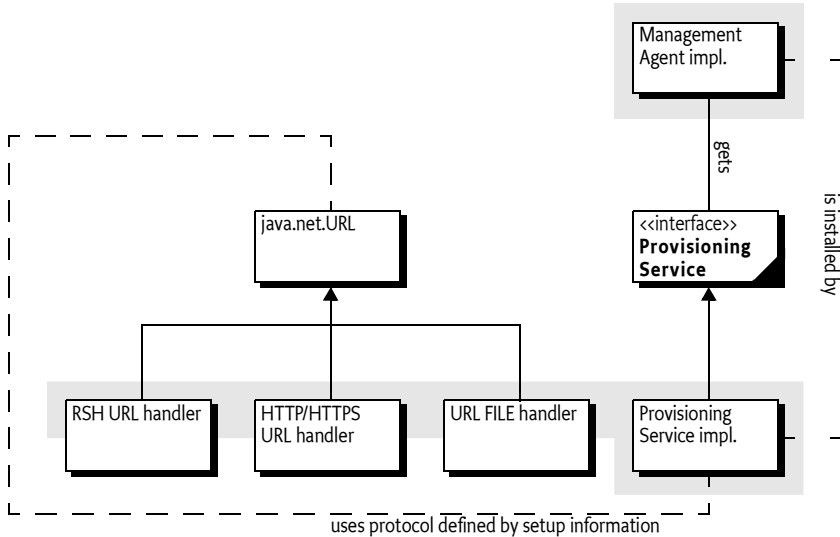
- *Policy Free* – The proposed solution must be business model agnostic; none of the affected parties (Operators, SPS Manufacturers, etc.) should be forced into any particular business model.
- *Interoperability* – The Initial Provisioning must permit arbitrary interoperability between management systems and Service Platforms. Any compliant Remote Manager should be able to manage any compliant Service Platform, even in the absence of a prior business relationship. Adhering to this requirement allows a particular Operator to manage a variety of makes and models of Service Platform Servers using a single management system of the Operator's choice. This rule also gives the consumer the greatest choice when selecting an Operator.
- *Flexible* – The management process should be as open as possible, to allow innovation and specialization while still achieving interoperability.

110.1.2 Entities

- *Provisioning Service* – A service registered with the Framework that provides information about the initial provisioning to the Management Agent.

- *Provisioning Dictionary* – A Dictionary object that is filled with information from the ZIP files that are loaded during initial setup.
- *RSH Protocol* – An OSGi specific secure protocol based on HTTP.
- *Management Agent* – A bundle that is responsible for managing a Service Platform under control of a Remote Manager.

Figure 39 Initial Provisioning



110.2 Procedure

The following procedure should be executed by an OSGi Framework implementation that supports this Initial Provisioning specification.

When the Service Platform is first brought under management control, it must be provided with an initial request URL in order to be provisioned. Either the end user or the manufacturer may provide the initial request URL. How the initial request URL is transferred to the Framework is not specified, but a mechanism might, for example, be a command line parameter when the framework is started.

When asked to start the Initial Provisioning, the Service Platform will send a request to the management system. This request is encoded in a URL, for example:

```
http://osgi.acme.com/remote-manager
```

This URL may use any protocol that is available on the Service Platform Server. Many standard protocols exist, but it is also possible to use a proprietary protocol. For example, software could be present which can communicate with a smart card and could handle, for example, this URL:

```
smart-card://com1:0/7F20/6F38
```


Before the request URL is executed, the Service Platform information is appended to the URL. This information includes at least the Service Platform Identifier, but may also contain proprietary information, as long as the keys for this information do not conflict. Different URL schemes may use different methods of appending parameters; these details are specified in the mappings of this specification to concrete protocols.

The result of the request must be a ZIP file (The content type should be application/zip). It is the responsibility of the underlying protocol to guarantee the integrity and authenticity of this ZIP file.

This ZIP file is unpacked and its entries (except bundle and bundle-url entries, described in Table 21) are placed in a Dictionary object. This Dictionary object is called the *Provisioning Dictionary*. It must be made available from the Provisioning Service in the service registry. The names of the entries in the ZIP file must not start with a slash ('/').

The ZIP file may contain only four types of dictionary entries: text, binary, bundle, or bundle-url. The types are specified in the ZIP entry's extra field, and must be a MIME type as defined in [38] *MIME Types*. The text and bundle-url entries are translated into a String object. All other entries must be stored as a byte[].

Table 20 Content types of provisioning ZIP file

Type	MIME Type	Description
text	MIME_STRING text/plain; charset=utf-8	Must be represented as a String object
binary	MIME_BYTE_ARRAY application/octet-stream	Must be represented as a byte array (byte[]).
bundle	MIME_BUNDLE application/x-osgi-bundle	Entries must be installed using BundleContext.installBundle(String, InputStream), with the InputStream object constructed from the contents of the ZIP entry. The location must be the name of the ZIP entry without leading slash. This entry must not be stored in the Provisioning Dictionary. If a bundle with this location name is already installed in this system, then this bundle must be updated instead of installed.
bundle-url	MIME_BUNDLE_URL text/x-osgi-bundle-url; charset=utf-8	The content of this entry is a string coded in utf-8. Entries must be installed using BundleContext.installBundle(String, InputStream), with the InputStream object created from the given URL. The location must be the name of the ZIP entry without leading slash. This entry must not be stored in the Provisioning Dictionary. If a bundle with this location url is already installed in this system, then this bundle must be updated instead of installed.

The Provisioning Service must install (but not start) all entries in the ZIP file that are typed in the extra field with bundle or bundle-url.

If an entry named `PROVISIONING_START_BUNDLE` is present in the Provisioning Dictionary, then its content type must be text as defined in Table 20. The content of this entry must match the bundle location of a previously loaded bundle. This designated bundle must be given AllPermission and started.

If no `PROVISIONING_START_BUNDLE` entry is present in the Provisioning Dictionary, the Provisioning Dictionary should contain a reference to another ZIP file under the `PROVISIONING_REFERENCE` key. If both keys are absent, no further action must take place.

If this `PROVISIONING_REFERENCE` key is present and holds a String object that can be mapped to a valid URL, then a new ZIP file must be retrieved from this URL. The `PROVISIONING_REFERENCE` link may be repeated multiple times in successively loaded ZIP files.

Referring to a new ZIP file with such a URL allows a manufacturer to place a fixed reference inside the Service Platform Server (in a file or smart card) that will provide some platform identifying information and then also immediately load the information from the management system. The `PROVISIONING_REFERENCE` link may be repeated multiple times in successively loaded ZIP files. The entry `PROVISIONING_UPDATE_COUNT` must be an Integer object that must be incremented on every iteration.

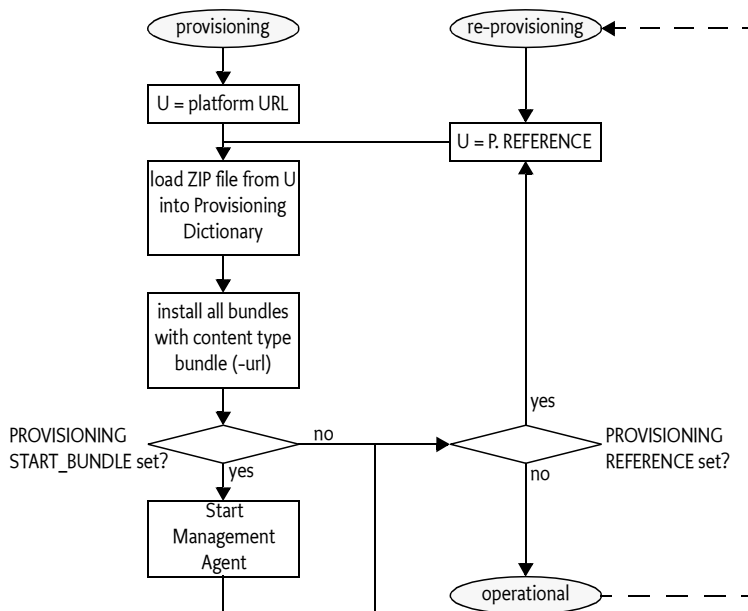
Information retrieved while loading subsequent `PROVISIONING_REFERENCE` URLs may replace previous key/values in the Provisioning Dictionary, but must not erase unrecognized key/values. For example, if an assignment has assigned the key `proprietary-x`, with a value '3', then later assignments must not override this value, unless the later loaded ZIP file contains an entry with that name. All these updates to the Provisioning Dictionary must be stored persistently. At the same time, each entry of type bundle or bundle-url (see Table 20) must be installed and not started.

Once the Management Agent has been started, the Initial Provisioning service has become operational. In this state, the Initial Provisioning service must react when the Provisioning Dictionary is updated with a new `PROVISIONING_REFERENCE` property. If this key is set, it should start the cycle again. For example, if the control of a Service Platform needs to be transferred to another Remote Manager, the Management Agent should set the `PROVISIONING_REFERENCE` to the location of this new Remote Manager's Initial Provisioning ZIP file. This process is called *re-provisioning*.

If errors occur during this process, the Initial Provisioning service should try to notify the Service User of the problem.

The previous description is depicted in Figure 40 as a flow chart.

Figure 40 Flow chart installation Management Agent bundle



The Management Agent may require configuration data that is specific to the Service Platform instance. If this data is available outside the Management Agent bundle, the merging of this data with the Management Agent may take place in the Service Platform. Transferring the data separately will make it possible to simplify the implementation on the server side, as it is not necessary to create *personalized* Service Platform bundles. The [PROVISIONING_AGENT_CONFIG](#) key is reserved for this purpose, but the Management Agent may use another key or mechanisms if so desired.

The [PROVISIONING_SPID](#) key must contain the Service Platform Identifier.

110.3 Special Configurations

The next section shows some examples of specially configured types of Service Platform Servers and how they are treated with the respect to the specifications in this document.

110.3.1 Branded Service Platform Server

If a Service Platform Operator is selling Service Platform Servers branded exclusively for use with their service, the provisioning will most likely be performed prior to shipping the Service Platform Server to the User. Typically the Service Platform is configured with the Dictionary entry [PROVISIONING_REFERENCE](#) pointing at a location controlled by the Operator.

Up-to-date bundles and additional configuration data must be loaded from that location at activation time. The Service Platform is probably equipped with necessary security entities, like certificates, to enable secure downloads from the Operator's URL over open networks, if necessary.

110.3.2 Non-connected Service Platform

Circumstances might exist in which the Service Platform Server has no WAN connectivity, or prefers not to depend on it for the purposes not covered by this specification.

The non-connected case can be implemented by specifying a `file://` URL for the initial ZIP file ([PROVISIONING_REFERENCE](#)). That `file://` URL would name a local file containing the response that would otherwise be received from a remote server.

The value for the Management Agent [PROVISIONING_REFERENCE](#) found in that file will be used as input to the load process. The [PROVISIONING_REFERENCE](#) may point to a bundle file stored either locally or remotely. No code changes are necessary for the non-connected scenario. The `file://` URLs must be specified, and the appropriate files must be created on the Service Platform.

110.4 The Provisioning Service

Provisioning information is conveyed between bundles using the Provisioning Service, as defined in the [ProvisioningService](#) interface. The Provisioning Dictionary is retrieved from the ProvisioningService object using the [getInformation\(\)](#) method. This is a read-only Dictionary object, any changes to this Dictionary object must throw an `UnsupportedOperationException`.

The Provisioning Service provides a number of methods to update the Provisioning Dictionary.

- [addInformation\(Dictionary\)](#) – Add all key/value pairs in the given Dictionary object to the Provisioning Dictionary.
- [addInformation\(InputStream\)](#) – It is also possible to add a ZIP file to the Provisioning Service immediately. This will unpack the ZIP file and add the entries to the Provisioning Dictionary. This method must install the bundles contained in the ZIP file as described in *Procedure* on page 230.
- [setInformation\(Dictionary\)](#) – Set a new Provisioning Dictionary. This will remove all existing entries.

Each of these method will increment the [PROVISIONING_UPDATE_COUNT](#) entry.

110.5 Management Agent Environment

The Management Agent should be written with great care to minimize dependencies on other packages and services, as *all* services in OSGi are optional. Some Service Platforms may have other bundles pre-installed, so it is possible that there may be exported packages and services available. Mechanisms outside the current specification, however, must be used to discover these packages and services before the Management Agent is installed.

The Provisioning Service must ensure that the Management Agent is running with `AllPermission`. The Management Agent should check to see if the `PermissionAdmin` service is available, and establish the initial permissions as soon as possible to insure the security of the device when later bundles are installed. As the `PermissionAdmin` interfaces may not be present (it is an optional service), the Management Agent should export the `PermissionAdmin` interfaces to ensure they can be resolved.

Once started, the Management Agent may retrieve its configuration data from the Provisioning Service by getting the `byte[]` object that corresponds to the `PROVISIONING_AGENT_CONFIG` key in the Provisioning Dictionary. The structure of the configuration data is implementation specific.

The scope of this specification is to provide a mechanism to transmit the raw configuration data to the Management Agent. The Management Agent bundle may alternatively be packaged with its configuration data in the bundle, so it may not be necessary for the Management Agent bundle to use the Provisioning Service at all.

Most likely, the Management Agent bundle will install other bundles to provision the Service Platform. Installing other bundles might even involve downloading a more full featured Management Agent to replace the initial Management Agent.

110.6 Mapping To File Scheme

The `file:` scheme is the simplest and most completely supported scheme which can be used by the Initial Provisioning specification. It can be used to store the configuration data and Management Agent bundle on the Service Platform Server, and avoids any outside communication.

If the initial request URL has a file scheme, no parameters should be appended, because the `file:` scheme does not accept parameters.

110.6.1 Example With File Scheme

The manufacturer should prepare a ZIP file containing only one entry named `PROVISIONING_START_BUNDLE` that contains a location string of an entry of type `application/x-osi-bundle` or `application/x-osi-bundle-URL`. For example, the following ZIP file demonstrates this:

<code>provisioning.start.bundle</code>	<code>text</code>	<code>agent</code>
<code>agent</code>	<code>bundle</code>	<code>COAF0E9B2AB..</code>

The bundle may also be specified with a URL:

```
provisioning.start.bundle text http://acme.com/a.jar
agent bundle-url http://acme.com/a.jar
```

Upon startup, the framework is provided with the URL with the file:
scheme that points to this ZIP file:

```
file:/opt/osgi/ma.zip
```

110.7 Mapping To HTTP(S) Scheme

This section defines how HTTP and HTTPS URLs must be used with the Initial Provisioning specification.

- HTTP – May be used when the data exchange takes place over networks that are secured by other means, such as a Virtual Private Network (VPN) or a physically isolated network. Otherwise, HTTP is not a valid scheme because no authentication takes place.
- HTTPS – May be used if the Service Platform is equipped with appropriate certificates.

HTTP and HTTPS share the following qualities:

- Both are well known and widely used
- Numerous implementations of the protocols exist
- Caching of the Management Agent will be desired in many implementations where limited bandwidth is an issue. Both HTTP and HTTPS already contain an accepted protocol for caching.

Both HTTP and HTTPS must be used with the GET method. The response is a ZIP file, implying that the response header Content-Type header must contain application/zip.

110.7.1 HTTPS Certificates

In order to use HTTPS, certificates must be in place. These certificates, that are used to establish trust towards the Operator, may be made available to the Service Platform using the Provisioning Service. The root certificate should be assigned to the Provisioning Dictionary before the HTTPS provider is used. Additionally, the Service Platform should be equipped with a Service Platform certificate that allows the Service Platform to properly authenticate itself towards the Operator. This specification does not state how this certificate gets installed into the Service Platform.

The root certificate is stored in the Provisioning Dictionary under the key:

PROVISIONING_ROOTX509

The Root X.509 Certificate holds certificates used to represent a handle to a common base for establishing trust. The certificates are typically used when authenticating a Remote Manager to the Service Platform. In this case, a Root X.509 certificate must be part of a certificate chain for the Operator's certificate. The format of the certificate is defined in *Certificate Encoding* on page 237.

110.7.2 Certificate Encoding

Root certificates are X.509 certificates. Each individual certificate is stored as a `byte[]` object. This `byte[]` object is encoded in the default Java manner, as follows:

- The original, binary certificate data is DER encoded
- The DER encoded data is encoded into base64 to make it text.
- The base64 encoded data is prefixed with
-----BEGIN CERTIFICATE-----
and suffixed with:
-----END CERTIFICATE-----
- If a record contains more than one certificate, they are simply appended one after the other, each with a delimiting prefix and suffix.

The decoding of such a certificate may be done with the `java.security.cert.CertificateFactory` class:

```
InputStream bis = new ByteArrayInputStream(x509); // byte []
CertificateFactory cf =
    CertificateFactory.getInstance("X.509");
Collection c = cf.generateCertificates(bis);
Iterator i = c.iterator();
while (i.hasNext()) {
    Certificate cert = (Certificate)i.next();
    System.out.println(cert);
}
```

110.7.3 URL Encoding

The URL must contain the Service Platform Identity, and may contain more parameters. These parameters are encoded in the URL according to the HTTP(S) URL scheme. A base URL may be set by an end user but the Provisioning Service must add the Service Platform Identifier.

If the request URL already contains HTTP parameters (if there is a '?' in the request), the `service_platform_id` is appended to this URL as an additional parameter. If, on the other hand, the request URL does not contain any HTTP parameters, the `service_platform_id` will be appended to the URL after a '?', becoming the first HTTP parameter. The following two examples show these two variants:

```
http://server.operator.com/service-x? «
foo=bar&service_platform_id=VIN:123456789
```

```
http://server.operator.com/service-x? «
service_platform_id=VIN:123456789
```

Proper URL encoding must be applied when the URL contains characters that are not allowed. See [37] *RFC 2396 - Uniform Resource Identifier (URI)*.

110.8 Mapping To RSH Scheme

The RSH protocol is an OSGi-specific protocol, and is included in this specification because it is optimized for Initial Provisioning. It requires a shared secret between the management system and the Service Platform that is small enough to be entered by the Service User.

RSH bases authentication and encryption on Message Authentication Codes (MACs) that have been derived from a secret that is shared between the Service Platform and the Operator prior to the start of the protocol execution.

The protocol is based on an ordinary HTTP GET request/response, in which the request must be *signed* and the response must be *encrypted* and *authenticated*. Both the *signature* and *encryption key* are derived from the shared secret using Hashed Message Access Codes (HMAC) functions.

As additional input to the HMAC calculations, one client-generated nonce and one server-generated nonce are used to prevent replay attacks. The nonces are fairly large random numbers that must be generated in relation to each invocation of the protocol, in order to guarantee freshness. These nonces are called *clientfg* (client-generated freshness guarantee) and *serverfg* (server-generated freshness guarantee).

In order to separate the HMAC calculations for authentication and encryption, each is based on a different constant value. These constants are called the *authentication constant* and the *encryption constant*.

From an abstract perspective, the protocol may be described as follows.

- δ – Shared secret, 160 bits or more
- s – Server nonce, called *servercfg*, 128 bits
- c – Client nonce, called *clientfg*, 128 bits
- K_a – Authentication key, 160 bits
- K_e – Encryption key, 192 bits
- r – Response data
- e – Encrypted data
- E – Encryption constant, a byte[] of 05, 36, 54, 70, 00 (hex)
- A – Authentication constant, a byte[] of 00, 4f, 53, 47, 49 (hex)
- M – Message material, used for K_e calculation.
- m – The calculated message authentication code.
- $3DES$ – Triple DES, encryption function, see [39] *3DES*. The bytes of the key must be set to odd parity. CBC mode must be used where the padding method is defined in [40] *RFC 1423 Part III: Algorithms, Modes, and Identifiers*. In [42] *Java Cryptography API (part of Java 1.4)* this is addressed as `PKCS5Padding`.
- IV – Initialization vector for 3DES.
- $SHA1$ – Secure Hash Algorithm to generate the Hashed Message Authentication Code, see [43] *SHA-1*. The function takes a single parameter, the block to be worked upon.
- $HMAC$ – The function that calculates a message authentication code, which must be `HMAC-SHA1`. `HMAC-SHA1` is defined in [32] *HMAC: Keyed-Hashing for Message Authentication*. The HMAC function takes a key and a block to be worked upon as arguments. Note that the lower 16 bytes of the result must be used.

- $\{\}$ – Concatenates its arguments
- $[]$ – Indicates access to a sub-part of a variable, in bytes. Index starts at one, not zero.

In each step, the emphasized server or client indicates the context of the calculation. If both are used at the same time, each variable will have server or client as a subscript.

1. The *client* generates a random nonce, stores it and denotes it *clientfg*

$$c = \text{nonce}$$

2. The client sends the request with the *clientfg* to the server.

$$c_{\text{server}} \leftarrow c_{\text{client}}$$

3. The *server* generates a nonce and denotes it *serverfg*.

$$s = \text{nonce}$$

4. The *server* calculates an authentication key based on the SHA1 function, the shared secret, the received *clientfg*, the *serverfg* and the authentication constant.

$$K_a \leftarrow \text{SHA1}(\{\delta, c, s, A\})$$

5. The *server* calculates an encryption key using an SHA-1 function, the shared secret, the received *clientfg*, the *serverfg* and the encryption constant. It must first calculate the *key material* *M*.

$$M[1, 20] \leftarrow \text{SHA1}(\{\delta, c, s, E\})$$

$$M[21, 40] \leftarrow \text{SHA1}(\{\delta, M[1, 20], c, s, E\})$$

6. The key for DES consists K_e and *IV*.

$$K_e \leftarrow M[1, 24]$$

$$IV \leftarrow M[25, 32]$$

The *server* encrypts the response data using the encryption key derived in 5. The encryption algorithm that must be used to encrypt/decrypt the response data is 3DES. 24 bytes (192 bits) from *M* are used to generate K_e , but the low order bit of each byte must be used as an odd parity bit. This means that before using K_e , each byte must be processed to set the low order bit so that the byte has odd parity.

The encryption/decryption key used is specified by the following:

$$e \leftarrow 3DES(K_e, IV, r)$$

7. The *server* calculates a MAC *m* using the HMAC function, the encrypted response data and the authentication key derived in 4.

$$m \leftarrow \text{HMAC}(K_a, e)$$

8. The *server* sends a response to the *client* containing the *serverfg*, the MAC *m* and the encrypted response data

$$s_{\text{client}} \leftarrow s_{\text{server}}$$

$$m_{\text{client}} \leftarrow m_{\text{server}}$$

$$e_{\text{client}} \leftarrow e_{\text{server}}$$

The *client* calculates the encryption key K_e the same way the server did in step 5 and 6. and uses this to decrypt the encrypted response data. The *serverfg* value received in the response is used in the calculation.

$$r \leftarrow 3DES(K_e, IV, e)$$

9. The *client* performs the calculation of the MAC m' in the same way the server did, and checks that the results match the received MAC m . If they do not match, further processing is discarded. The *serverfg* value received in the response is used in the calculation.

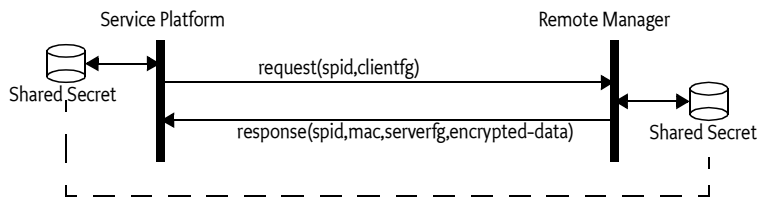
$$K_a \leftarrow SHA1(\{\delta, c, s, A\})$$

$$m' \leftarrow HMAC(K_a, e)$$

$$m' = m$$

Figure 41

Action Diagram for RSH



110.8.1

Shared Secret

The *shared secret* should be a key of length 160 bits (20 bytes) or more. The length is selected to match the output of the selected hash algorithm [33] *NIST, FIPS PUB 180-1: Secure Hash Standard, April 1995..*

In some scenarios, the shared secret is generated by the Operator and communicated to the User, who inserts the secret into the Service Platform through some unspecified means.

The opposite is also possible: the shared secret can be stored within the Service Platform, extracted from it, and then communicated to the Operator. In this scenario, the source of the shared secret could be either the Service Platform or the Operator.

In order for the server to calculate the authentication and encryption keys, it requires the proper shared secret. The server must have access to many different shared secrets, one for each Service Platform it is to support. To be able to resolve this issue, the server must typically also have access to the Service Platform Identifier of the Service Platform. The normal way for the server to know the Service Platform Identifier is through the application protocol, as this value is part of the URL encoded parameters of the HTTP, HTTPS, or RSH mapping of the Initial Provisioning.

In order to be able to switch Operators, a new shared secret must be used. The new secret may be generated by the new Operator and then inserted into the Service Platform device using a mechanism not covered by this specification. Or the device itself may generate the new secret and convey it

to the owner of the device using a display device or read-out, which is then communicated to the new operator out-of-band. Additionally, the generation of the new secret may be triggered by some external event, like holding down a button for a specified amount of time.

110.8.2 Request Coding

RSH is mapped to HTTP or HTTPS. Thus, the request parameters are URL encoded as discussed in 110.7.3 *URL Encoding*. RSH requires an additional parameter in the URL: the `clientfg` parameter. This parameter is a nonce that is used to counter replay attacks. See also *RSH Transport* on page 242.

110.8.3 Response Coding

The server’s response to the client is composed of three parts:

- A header containing the protocol version and the `serverfg`
- The MAC
- The encrypted response

These three items are packaged into a binary container according to Table 21.

Table 21 RSH Header description

Bytes	Description	Value hex
4	Number of bytes in header	2E
1	Major version number	01
1	Minor version number	00
16	<code>serverfg</code>	...
4	Number of bytes in MAC	10
16	Message Authentication Code	MAC
4	Number of bytes of encrypted ZIP file	N
N	Encrypted ZIP file	...

The response content type is an RSH-specific encrypted ZIP file, implying that the response header `Content-Type` must be `application/x-rsh` for the HTTP request. When the content file is decrypted, the content must be a ZIP file.

110.8.4 RSH URL

The RSH URL must be used internally within the Service Platform to indicate the usage of RSH for initial provisioning. The RSH URL format is identical to the HTTP URL format, except that the scheme is `rsh:` instead of `http:`. For example (`<` means line continues on next line):

```
rsh: //server.operator.com/service-x
```

110.8.5 Extensions to the Provisioning Service Dictionary

RSH specifies one additional entry for the Provisioning Dictionary:

```
PROVISIONING_RSH_SECRET
```

The value of this entry is a byte[] containing the shared secret used by the RSH protocol.

110.8.6 RSH Transport

RSH is mapped to HTTP or HTTPS and follows the same URL encoding rules, except that the clientfg is additionally appended to the URL. The key in the URL must be clientfg and the value must be encoded in base 64 format:

The clientfg parameter is transported as an HTTP parameter that is appended after the service_platform_id parameter. The second example above would then be:

```
rsh://server.operator.com/service-x
```

Which, when mapped to HTTP, must become:

```
http://server.operator.com/service-x? «
service_platform_id=VIN:123456789& «
clientfg=AHpmWcw%2FsiWYC37xZNdKvQ%3D%3D
```

110.9 Exception Handling

The Initial Provisioning process is a sensitive process that must run without user supervision. There is therefore a need to handle exceptional cases in a well defined way to simplify trouble shooting.

There are only 2 types of problems that halt the provisioning process. They are:

- IOException when reading or writing provisioning information.
- IOException when retrieving or processing a provisioning zip file.

Other exceptions can occur and the Provisioning Service must do any attempt to log these events.

In the cases that the provisioning process stops, it is important that the clients of the provisioning service have a way to find out that the process is stopped. The mechanism that is used for this is a special entry in the provisioning dictionary. The name of the entry must be provisioning.error. The value is a String object with the following format:

- Numeric error code
- Space
- A human readable string describing the error.

Permitted error codes are:

- 0 – Unknown error
- 1 – Couldn't load or save provisioning information
- 2 – MalformedURLException
- 3 – IOException when retrieving document of a URL
- 4 – Corrupted ZipInputStream

The provisioning.update.count will be incremented as normal when a provisioning.error entry is added to the provisioning information. After, the provisioning service will take no further action.

Some examples:

```
0 SIM card removed
2 "http://www.acme.com/secure/blib/ifa.zip"
```

110.10 Security

The security model for the Service Platform is based on the integrity of the Management Agent deployment. If any of the mechanisms used during the deployment of management agents are weak, or can be compromised, the whole security model becomes weak.

From a security perspective, one attractive means of information exchange would be a smart card. This approach enables all relevant information to be stored in a single place. The Operator could then provide the information to the Service Platform by inserting the smart card into the Service Platform.

110.10.1 Concerns

The major security concerns related to the deployment of the Management Agent are:

- The Service Platform is controlled by the intended Operator
- The Operator controls the intended Service Platform(s)
- The integrity and confidentiality of the information exchange that takes place during these processes must be considered

In order to address these concerns, an implementation of the OSGi Remote Management Architecture must assure that:

- The Operator authenticates itself to the Service Platform
- The Service Platform authenticates itself to the Operator
- The integrity and confidentiality of the Management Agent, certificates, and configuration data are fully protected if they are transported over public transports.

Each mapping of the Initial Provisioning specification to a concrete implementation must describe how these goals are met.

110.10.2 Service Platform Long-Term Security

Secrets for long-term use may be exchanged during the Initial Provisioning procedures. This way, one or more secrets may be shared securely, assuming that the Provisioning Dictionary assignments used are implemented with the proper security characteristics.

110.10.3 Permissions

The provisioning information may contain sensitive information. Also, the ability to modify provisioning information can have drastic consequences. Thus, only trusted bundles should be allowed to register, or get the Provisioning Service. This restriction can be enforced using `ServicePermission[ProvisioningService, GET]`.

No Permission classes guard reading or modification of the Provisioning Dictionary, so care must be taken not to leak the Dictionary object received from the Provisioning Service to bundles that are not trusted.

Whether message-based or connection-based, the communications used for Initial Provisioning must support mutual authentication and message integrity checking, at a minimum.

By using both server and client authentication in HTTPS, the problem of establishing identity is solved. In addition, HTTPS will encrypt the transmitted data. HTTPS requires a Public Key Infrastructure implementation in order to retrieve the required certificates.

When RSH is used, it is vital that the shared secret is shared only between the Operator and the Service Platform, and no one else.

110.11 Changes

The only change to the Initial Provisioning specification is the addition of extra information to find the cause of problems.

110.12 org.osgi.service.provisioning

The OSGi Provisioning Service Package. Specification Version 1.1.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

```
Import-Package: org.osgi.service.provisioning; version=1.1
```

110.12.1 public interface ProvisioningService

Service for managing the initial provisioning information.

Initial provisioning of an OSGi device is a multi step process that culminates with the installation and execution of the initial management agent. At each step of the process, information is collected for the next step. Multiple bundles may be involved and this service provides a means for these bundles to exchange information. It also provides a means for the initial Management Bundle to get its initial configuration information.

The provisioning information is collected in a Dictionary object, called the Provisioning Dictionary. Any bundle that can access the service can get a reference to this object and read and update provisioning information. The key of the dictionary is a String object and the value is a String or byte[] object. The single exception is the PROVISIONING_UPDATE_COUNT value which is an Integer. The provisioning prefix is reserved for keys defined by OSGi, other key names may be used for implementation dependent provisioning systems.

Any changes to the provisioning information will be reflected immediately in all the dictionary objects obtained from the Provisioning Service.

Because of the specific application of the Provisioning Service, there should be only one Provisioning Service registered. This restriction will not be enforced by the Framework. Gateway operators or manufacturers should ensure that a Provisioning Service bundle is not installed on a device that already has a bundle providing the Provisioning Service.

The provisioning information has the potential to contain sensitive information. Also, the ability to modify provisioning information can have drastic consequences. Thus, only trusted bundles should be allowed to register and get the Provisioning Service. The ServicePermission is used to limit the bundles that can gain access to the Provisioning Service. There is no check of Permission objects to read or modify the provisioning information, so care must be taken not to leak the Provisioning Dictionary received from getInformation method.

110.12.1.1 public static final String MIME_BUNDLE = "application/x-*osgi-bundle*"

MIME type to be stored in the extra field of a ZipEntry object for an installable bundle file. Zip entries of this type will be installed in the framework, but not started. The entry will also not be put into the information dictionary.

110.12.1.2 public static final String MIME_BUNDLE_URL = "text/x-*osgi-bundle-url*"

MIME type to be stored in the extra field of a ZipEntry for a String that represents a URL for a bundle. Zip entries of this type will be used to install (but not start) a bundle from the URL. The entry will not be put into the information dictionary.

110.12.1.3 public static final String MIME_BYTE_ARRAY = "application/*octet-stream*"

MIME type to be stored in the extra field of a ZipEntry object for byte[] data.

110.12.1.4 public static final String MIME_STRING = "text/plain; charset=*utf-8*"

MIME type to be stored in the extra field of a ZipEntry object for String data.

**110.12.1.5 public static final String PROVISIONING_AGENT_CONFIG =
"provisioning.agent.config"**

The key to the provisioning information that contains the initial configuration information of the initial Management Agent. The value will be of type byte[].

**110.12.1.6 public static final String PROVISIONING_REFERENCE =
"provisioning.reference"**

The key to the provisioning information that contains the location of the provision data provider. The value must be of type String.

**110.12.1.7 public static final String PROVISIONING_ROOTX509 =
"provisioning.rootx509"**

The key to the provisioning information that contains the root X509 certificate used to establish trust with operator when using HTTPS.

**110.12.1.8 public static final String PROVISIONING_RSH_SECRET =
"provisioning.rsh.secret"**

The key to the provisioning information that contains the shared secret used in conjunction with the RSH protocol.

-
- 110.12.1.9** **public static final String PROVISIONING_SPID = “provisioning.spid”**
- The key to the provisioning information that uniquely identifies the Service Platform. The value must be of type String.
- 110.12.1.10** **public static final String PROVISIONING_START_BUNDLE = “provisioning.start.bundle”**
- The key to the provisioning information that contains the location of the bundle to start with AllPermission. The bundle must have be previously installed for this entry to have any effect.
- 110.12.1.11** **public static final String PROVISIONING_UPDATE_COUNT = “provisioning.update.count”**
- The key to the provisioning information that contains the update count of the info data. Each set of changes to the provisioning information must end with this value being incremented. The value must be of type Integer. This key/value pair is also reflected in the properties of the ProvisioningService in the service registry.
- 110.12.1.12** **public void addInformation(Dictionary info)**
- info* the set of Provisioning Information key/value pairs to add to the Provisioning Information dictionary. Any keys are values that are of an invalid type will be silently ignored.
- Adds the key/value pairs contained in *info* to the Provisioning Information dictionary. This method causes the PROVISIONING_UPDATE_COUNT to be incremented.
- 110.12.1.13** **public void addInformation(ZipInputStream zis) throws IOException**
- zis* the ZipInputStream that will be used to add key/value pairs to the Provisioning Information dictionary and install and start bundles. If a ZipEntry does not have an Extra field that corresponds to one of the four defined MIME types (MIME_STRING, MIME_BYTE_ARRAY, MIME_BUNDLE, and MIME_BUNDLE_URL) in will be silently ignored.
- Processes the ZipInputStream and extracts information to add to the Provisioning Information dictionary, as well as, install/update and start bundles. This method causes the PROVISIONING_UPDATE_COUNT to be incremented.
- Throws* IOException – if an error occurs while processing the ZipInputStream. No additions will be made to the Provisioning Information dictionary and no bundles must be started or installed.
- 110.12.1.14** **public Dictionary getInformation()**
- Returns a reference to the Provisioning Dictionary. Any change operations (put and remove) to the dictionary will cause an UnsupportedOperationException to be thrown. Changes must be done using the setInformation and addInformation methods of this service.
- Returns* A reference to the Provisioning Dictionary.
-

110.12.1.15 public void setInformation(Dictionary info)

info the new set of Provisioning Information key/value pairs. Any keys are values that are of an invalid type will be silently ignored.

- Replaces the Provisioning Information dictionary with the key/value pairs contained in *info*. Any key/value pairs not in *info* will be removed from the Provisioning Information dictionary. This method causes the PROVISIONING_UPDATE_COUNT to be incremented.

110.13 References

- [32] *HMAC: Keyed-Hashing for Message Authentication*
<http://www.ietf.org/rfc/rfc2104.txt> Krawczyk, et. al. 1997.
- [33] *NIST, FIPS PUB 180-1: Secure Hash Standard, April 1995.*
- [34] *Hypertext Transfer Protocol - HTTP/1.1*
<http://www.ietf.org/rfc/rfc2616.txt> Fielding, R., et. al.
- [35] *Rescorla, E., HTTP over TLS, IETF RFC 2818, May 2000*
<http://www.ietf.org/rfc/rfc2818.txt>.
- [36] *ZIP Archive format*
<ftp://ftp.uu.net/pub/archiving/zip/doc/appnote-970311-iz.zip>
- [37] *RFC 2396 - Uniform Resource Identifier (URI)*
<http://www.ietf.org/rfc/rfc2396.txt>
- [38] *MIME Types*
<http://www.ietf.org/rfc/rfc2046.txt> and <http://www.iana.org/assignments/media-types>
- [39] *3DES*
W/ Tuchman, "Hellman Presents No Shortcut Solution to DES," IEEE Spectrum, v. 16, n. 7 July 1979, pp40-41.
- [40] *RFC 1423 Part III: Algorithms, Modes, and Identifiers*
<http://www.ietf.org/rfc/rfc1423.txt>
- [41] *PKCS 5*
<ftp://ftp.rsasecurity.com/pub/pkcs/pkcs-5v2>
- [42] *Java Cryptography API (part of Java 1.4)*
<http://java.sun.com/products/jce/index-14.html>
- [43] *SHA-1*
U.S. Government, Proposed Federal Information Processing Standard for Secure Hash Standard, January 1992
- [44] *Transport Layer Security*
<http://www.ietf.org/rfc/rfc2246.txt>, January 1999, The TLS Protocol Version 1.0, T. Dierks & C. Allen.

111 UPnP™ Device Service Specification

Version 1.1

111.1 Introduction

The UPnP Device Architecture specification provides the protocols for a peer-to-peer network. It specifies how to join a network and how devices can be controlled using XML messages sent over HTTP. The OSGi specifications address how code can be downloaded and managed in a remote system. Both standards are therefore fully complementary. Using an OSGi Service Platform to work with UPnP enabled devices is therefore a very successful combination.

This specification specifies how OSGi bundles can be developed that interoperate with UPnP™ (Universal Plug and Play) devices and UPnP control points. The specification is based on [45] *UPnP Device Architecture* and does not further explain the UPnP specifications. The UPnP specifications are maintained by [46] *UPnP Forum*.

UPnP™ is a trademark of the UPnP Implementers Corporation.

111.1.1 Essentials

- *Scope* – This specification is limited to device control aspects of the UPnP specifications. Aspects concerning the TCP/IP layer, like DHCP and limited TTL, are not addressed.
- *Transparency* – OSGi services should be made available to networks with UPnP enabled devices in a transparent way.
- *Network Selection* – It must be possible to restrict the use of the UPnP protocols to a selection of the connected networks. For example, in certain cases OSGi services that are UPnP enabled should not be published to the Wide Area Network side of a gateway, nor should UPnP devices be detected on this WAN.
- *Event handling* – Bundles must be able to listen to UPnP events.
- *Export OSGi services as UPnP devices* – Enable bundles that make a service available to UPnP control points.
- *Implement UPnP Control Points* – Enable bundles that control UPnP devices.

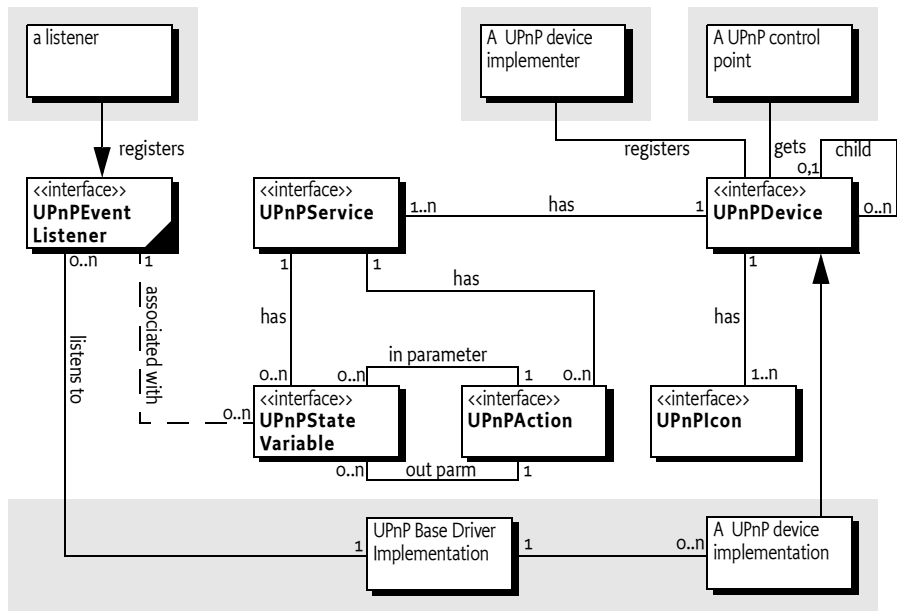
111.1.2 Entities

- *UPnP Base Driver* – The bundle that implements the bridge between OSGi and UPnP networks. This entity is not represented as a service.
- *UPnP RootDevice* – A physical device can contain one or more root devices. Root devices contain one or more devices. A root device is mod-

elled with a UPnPDevice object, there is no separate interface defined for root devices.

- *UPnP Device* – The representation of a UPnP device. A UPnP device may contain other UPnP devices and UPnP services. This entity is represented by a UPnPDevice object.
- *UPnP Service* – A UPnP device consists of a number of services. A UPnP service has a number of UPnP state variables that can be queried and modified with actions. This concept is represented by a UPnPService object.
- *UPnP Action* – A UPnP service is associated with a number of actions that can be performed on that service and that may modify the UPnP state variables. This entity is represented by a UPnPAction object.
- *UPnP State Variable* – A variable associated with a UPnP service, represented by a UPnPStateVariable object.
- *UPnPLocalStateVariable* – Extends the UPnPStateVariable interface when the state variable is implemented locally. This interface provides access to the actual value.
- *UPnP Event Listener Service* – A listener to events coming from UPnP devices.
- *UPnP Host* – The machine that hosts the code to run a UPnP device or control point.
- *UPnP Control Point* – A UPnP device that is intended to control UPnP devices over a network. For example, a UPnP remote controller.
- *UPnP Icon* – A representation class for an icon associated with a UPnP device.
- *UPnPException* – An exception that delivers errors that were discovered in the UPnP layer.
- *UDN* – Unique Device Name, a name that uniquely identifies the a specific device.

Figure 42 UPnP Service Specification class Diagram org.osgi.service.upnp package



111.1.3 Operation Summary

To make a UPnP service available to UPnP control points on a network, an OSGi service object must be registered under the UPnPDevice interface with the Framework. The UPnP driver bundle must detect these UPnP Device services and must make them available to the network as UPnP devices using the UPnP protocol.

UPnP devices detected on the local network must be detected and automatically registered under the UPnPDevice interface with the Framework by the UPnP driver implementation bundle.

A bundle that wants to control UPnP devices, for example to implement a UPnP control point, should track UPnP Device services in the OSGi service registry and control them appropriately. Such bundles should not distinguish between resident or remote UPnP Device services.

111.2 UPnP Specifications

The UPnP DA is intended to be used in a broad range of device from the computing (PCs printers), consumer electronics (DVD, TV, radio), communication (phones) to home automation (lighting control, security) and home appliances (refridgerators, coffeemakers) domains.

For example, a UPnP TV might announce its existence on a network by broadcasting a message. A UPnP control point on that network can then discover this TV by listening to those announce messages. The UPnP specifications allow the control point to retrieve information about the user interface of the TV. This information can then be used to allow the end user to control the remote TV from the control point, for example turn it on or change the channels.

The UPnP specification supports the following features:

- *Detect and control a UPnP standardized device.* In this case the control point and the remote device share a priori knowledge about how the device should be controlled. The UPnP Forum intends to define a large number of these standardized devices.
- *Use a user interface description.* A UPnP control point receives enough information about a device and its services to automatically build a user interface for it.
- *Programmatic Control.* A program can directly control a UPnP device without a user interface. This control can be based on detected information about the device or through a priori knowledge of the device type.
- *Allows the user to browse a web page supplied by the device.* This web page contains a user interface for the device that be directly manipulated by the user. However, this option is not well defined in the UPnP Device Architecture specification and is not tested for compliance.

The UPnP Device Architecture specification and the OSGi Service Platform provide *complementary* functionality. The UPnP Device Architecture specification is a data communication protocol that does not specify where and how programs execute. That choice is made by the implementations. In contrast, the OSGi Service Platform specifies a (managed) execution point and does not define what protocols or media are supported. The UPnP specification and the OSGi specifications are fully complementary and do not overlap.

From the OSGi perspective, the UPnP specification is a communication protocol that can be implemented by one or more bundles. This specification therefore defines the following:

- How an OSGi bundle can implement a service that is exported to the network via the UPnP protocols.
- How to find and control services that are available on the local network.

The UPnP specifications related to the assignment of IP addresses to new devices on the network or auto-IP self configuration should be handled at the operating system level. Such functions are outside the scope of this specification.

111.2.1

UPnP Base Driver

The functionality of the UPnP service is implemented in a UPnP *base driver*. This is a bundle that implements the UPnP protocols and handles the interaction with bundles that use the UPnP devices. A UPnP base driver bundle must provide the following functions:

- Discover UPnP devices on the network and map each discovered device into an OSGi registered UPnP Device service.
- Present UPnP marked services that are registered with the OSGi Framework on one or more networks to be used by other computers.

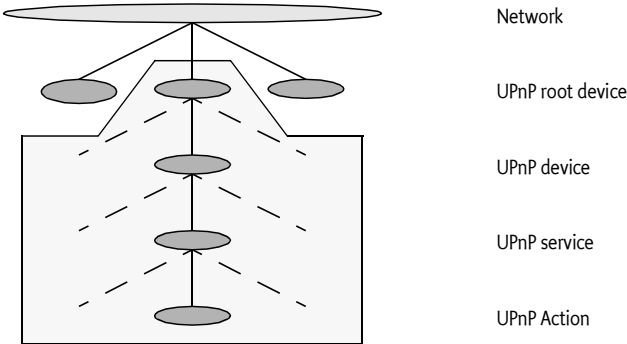
111.3

UPnP Device

The principle entity of the UPnP specification is the UPnP device. There is a UPnP *root device* that represents a physical appliance, such as a complete TV. The root device contains a number of sub-devices. These might be the tuner, the monitor, and the sound system. Each sub-device is further composed of a number of UPnP services. A UPnP service represents some functional unit in a device. For example, in a TV tuner it can represent the TV channel selector. Figure 43 on page 253 illustrates this hierarchy.

Figure 43

UPnP device hierarchy



Each UPnP service can be manipulated with a number of UPnP actions. UPnP actions can modify the state of a UPnP state variable that is associated with a service. For example, in a TV there might be a state variable *volume*. There are then actions to set the volume, to increase the volume, and to decrease the volume.

111.3.1

Root Device

The UPnP root device is registered as a UPnP Device service with the Framework, as well as all its sub-devices. Most applications will work with sub-devices, and, as a result, the children of the root device are registered under the UPnPDevice interface.

UPnP device properties are defined per sub-device in the UPnP specification. These properties must be registered with the OSGi Framework service registry so they are searchable.

Bundles that want to handle the UPnP device hierarchy can use the registered service properties to find the parent of a device (which is another registered UPnPDevice).

The following service registration properties can be used to discover this hierarchy:

- **PARENT_UDN** – The Universal Device Name (UDN) of the parent device. A root device must not have this property registered. Type is a String object.
- **CHILDREN_UDN** – An array of UDNs of this device's children. Type is a String[] object.

111.3.2 Exported Versus Imported Devices

Both imported (from the network to the OSGi service registry) and exported (from the service registry to the network) UPnPDevice services must have the same representation in the OSGi Service Platform for identical devices. For example, if an OSGi UPnP Device service is exported as a UPnP device from an OSGi Service Platform to the network, and it is imported into another OSGi Service Platform, the object representation should be equal. Application bundles should therefore be able to interact with imported and exported forms of the UPnP device in the same manner.

Imported and exported UPnP devices differ only by two marker properties that can be added to the service registration. One marker, **DEVICE_CATEGORY**, should typically be set only on imported devices. By not setting **DEVICE_CATEGORY** on internal UPnP devices, the Device Manager does not try to refine these devices (See the *Device Access Specification* on page 33 for more information about the Device Manager). If the device service does not implement the Device interface and does not have the **DEVICE_CATEGORY** property set, it is not considered a *device* according to the Device Access Specification.

The other marker, **UPNP_EXPORT**, should only be set on internally created devices that the bundle developer wants to export. By not setting **UPNP_EXPORT** on registered UPnP Device services, the UPnP Device service can be used by internally created devices that should not be exported to the network. This allows UPnP devices to be simulated within an OSGi Service Platform without announcing all of these devices to any networks.

111.3.3 Icons

A UPnP device can optionally support an icon. The purpose of this icon is to identify the device on a UPnP control point. UPnP control points can be implemented in large computers like PC's or simple devices like a remote control. However, the graphic requirements for these UPnP devices differ tremendously. The device can, therefore, export a number of icons of different size and depth.

In the UPnP specifications, an icon is represented by a URL that typically refers to the device itself. In this specification, a list of icons is available from the UPnP Device service.

In order to obtain localized icons, the method **getIcons(String)** can be used to obtain different versions. If the locale specified is a null argument, then the call returns the icons of the default locale of the called device (not the default locale of the UPnP control point). When a bundle wants to access the icon of an imported UPnP device, the UPnP driver gets the data and presents it to the application through an input stream.

A bundle that needs to export a UPnP Device service with one or more icons must provide an implementation of the `UPnPIcon` interface. This implementation must provide an `InputStream` object to the actual icon data. The UPnP driver bundle must then register this icon with an HTTP server and include the URL to the icon with the UPnP device data at the appropriate place.

111.4 Device Category

UPnP Device services are devices in the context of the Device Manager. This means that these services need to register with a number of properties to participate in driver refinement. The value for UPnP devices is defined in the `UPnPDevice` constant `DEVICE_CATEGORY`. The value is `UPnP`. The `UPnPDevice` interface contains a number of constants for matching values. Refer to `MATCH_GENERIC` on page 263 for further information.

111.5 UPnPService

A UPnP Device contains a number of `UPnPService` objects. `UPnPService` objects combine actions and state variables.

111.5.1 State Variables

The `UPnPStateVariable` interface encapsulates the properties of a UPnP state variable. In addition to the properties defined by the UPnP specification, a state variable is also mapped to a Java data type. The Java data type is used when an event is generated for this state variable and when an action is performed containing arguments related to this state variable. There must be a strict correspondence between the UPnP data type and the Java data type so that bundles using a particular UPnP device profile can predict the precise Java data type.

The function `QueryStateVariable` defined in the UPnP specification has been deprecated and is therefore not implemented. It is recommended to use the UPnP event mechanism to track UPnP state variables.

Additionally, a `UPnPStateVariable` object can also implement the `UPnPLocalStateVariable` interface if the device is implemented locally. That is, the device is not imported from the network. The `UPnPLocalStateVariable` interface provides a `getCurrentValue()` method that provides direct access to the actual value of the state variable.

111.6 Working With a UPnP Device

The UPnP driver must register all discovered UPnP devices in the local networks. These devices are registered under a `UPnPDevice` interface with the OSGi Framework.

Using a remote UPnP device thus involves tracking UPnP Device services in the OSGi service registry. The following code illustrates how this can be done. The sample Controller class extends the ServiceTracker class so that it can track all UPnP Device services and add them to a user interface, such as a remote controller application.

```
class Controller extends ServiceTracker {
    UI      ui;

    Controller( BundleContext context ) {
        super( context, UPnPDevice.class.getName(), null );
    }
    public Object addingService( ServiceReference ref ) {
        UPnPDevice dev = (UPnPDevice)super.addingService(ref);
        ui.addDevice( dev );
        return dev;
    }
    public void removedService( ServiceReference ref,
        Object dev ) {
        ui.removeDevice( (UPnPDevice) dev );
    }
    ...
}
```

111.7 Implementing a UPnP Device

OSGi services can also be exported as UPnP devices to the local networks, in a way that is transparent to typical UPnP devices. This allows developers to bridge legacy devices to UPnP networks. A bundle should perform the following to export an OSGi service as a UPnP device:

- Register an UPnP Device service with the registration property `UPNP_EXPORT`.
- Use the registration property `PRESENTATION_URL` to provide the presentation page. The service implementer must register its own servlet with the Http Service to serve out this interface. This URL must point to that servlet.

There can be multiple UPnP root devices hosted by one OSGi platform. The relationship between the UPnP devices and the OSGi platform is defined by the `PARENT_UDN` and `CHILDREN_UDN` service properties. The bundle registering those device services must make sure these properties are set accordingly.

Devices that are implemented on the OSGi Service Platform (in contrast with devices that are imported from the network) should use the `UPnPLocalStateVariable` interface for their state variables instead of the `UPnPStateVariable` interface. This interface provides programmatic access to the actual value of the state variable as maintained by the device specific code.

111.8 Event API

UPnP events are sent using the whiteboard model, in which a bundle interested in receiving the UPnP events registers an object implementing the `UPnPEventListener` interface. A filter can be set to limit the events for which a bundle is notified.

If a service is registered with a property named `upnp.filter` with the value of an instance of an `Filter` object, the listener is only notified for matching events (This is a `Filter` object and not a `String` object because it allows the `InvalidSyntaxException` to be thrown in the client and not the UPnP driver bundle).

The filter might refer to any valid combination of the following pseudo properties for event filtering:

- `UPnPDevice.UDN` – (`UPnP.device.UDN`) Only events generated by services contained in the specific device are delivered. For example: (`UPnP.device.UDN=uuid:Upnp-TVEulator-1_0-1234567890001`)
- `UPnPDevice.TYPE` – (`UPnP.device.type`) Only events generated by services contained in a device of the given type are delivered. For example: (`UPnP.device.type=urn:schemas-upnp-org:device:tvdevice:1`)
- `UPnPService.ID` – (`UPnP.service.id`) Service identity. Only events generated by services matching the given service ID are delivered.
- `UPnPService.TYPE` – (`UPnP.service.type`) Only events generated by services of of the given type are delivered.

If an event is generated, the `notifyUPnPEvent(String,String,Dictionary)` method is called on all registered `UPnPEventListener` services for which the optional filter matches for that event. If no filter is specified, all events must be delivered. If the filter does not match, the UPnP driver must not call the UPnP Event Listener service.

One or multiple events are passed as parameters to the `notifyUPnPEvent(String,String,Dictionary)` method. The Dictionary object holds a pair of `UPnPStateVariable` objects that triggered the event and an Object for the new value of the state variable.

111.8.1 Initial Event Delivery

Special care must be taken with the initial subscription to events. According to the UPnP specification, when a client subscribes for notification of events for the first time, the device sends out a number of events for each state variable, indicating the current status of each state variable. This behavior simplifies the synchronization of a device and an event-driven client.

The UPnP Driver must mimic this event distribution for all UPnP Event Listener services when they are registered. The driver must guarantee the same behavior for all registrations by keeping an internal history of the events. If a device uses the `UPnPLocalStateVariable` interface, the UPnP driver must query the actual value of the state variable before sending it to the newly registered listener. The driver must not rely on any maintained state.

The call to the listener's notification method must be done asynchronously.

111.9 UPnP Events and Event Admin service

UPnP events are delivered asynchronously to the Event Admin service.
UPnP events have the following topic:

```
org/osgi/service/upnp/UPnPEvent
```

The properties of a UPnP event are the following:

- upnp.deviceId – (String) The identity as defined by UPnPDevice.[UDN](#) of the device sending the event.
- upnp.serviceId – (String) The identity of the service sending the events.
- upnp.events – (Dictionary) A Dictionary object containing the new values for the state variables that have changed.

111.10 Localization

All values of the UPnP properties are obtained from the device using the device's default locale. If an application wants to query a set of localized property values, it has to use the method [getDescriptions\(String\)](#). For localized versions of the icons, the method [getIcons\(String\)](#) is to be used.

111.11 Dates and Times

The UPnP specification uses different types for date and time concepts. An overview of these types is given in Table 22 on page 258.

Table 22

UPnP Type
date
dateTime
dateTime.tz
time
time.tz

Mapping UPnP Date/Time types to Java

Class	Example	Value (TZ=CEST= +0200)
Date	1985-04-12	Sun April 12 00:00:00 CEST 1985
Date	1985-04-12T10:15:30	Sun April 12 10:15:30 CEST 1985
Date	1985-04-12T10:15:30+0400	Sun April 12 08:15:30 CEST 1985
Long	23:20:50	84.050.000 (ms)
Long	23:20:50+0300	1.250.000 (ms)

The UPnP specification points to [50] *XML Schema*. In this standard, [51] *ISO 8601 Date And Time formats* are referenced. The mapping is not completely defined which means that the this OSGi UPnP specification defines a complete mapping to Java classes. The UPnP types date, dateTime and dateTime.tz are represented as a Date object. For the date type, the hours, minutes and seconds must all be zero.

The UPnP types time and time.tz are represented as a Long object that represents the number of ms since midnight. If the time wraps to the next day due to a time zone value, then the final value must be truncated to modulo 86.400.000.

See also *TYPE_DATE* on page 271 and further.

111.12 UPnP Exception

The UPnP Exception can be thrown when a UPnPAction is invoked. This exception contains information about the different UPnP layers. The following errors are defined:

INVALID_ACTION – (401) No such action could be found.

INVALID_ARGS – (402) Invalid argument.

INVALID_SEQUENCE_NUMBER – (403) Out of synchronization.

INVALID_VARIABLE – (404) State variable not found.

DEVICE_INTERNAL_ERROR – (501) Internal error.

Further errors are categorized as follows:

- *Common Action Errors* – In the range of 600-69, defined by the UPnP Forum Technical Committee.
- *Action Specific Errors* – In the range of 700-799, defined by the UPnP Forum Working Committee.
- *Non-Standard Action Specific Errors* – In the range of 800-899. Defined by vendors.

111.13 Configuration

In order to provide a standardized way to configure a UPnP driver bundle, the Configuration Admin property `upnp.ssdp.address` is defined.

The value is a `String[]` with a list of IP addresses, optionally followed with a colon (':', \u003A) and a port number. For example:

239.255.255.250:1900

Those addresses define the interfaces which the UPnP driver is operating on. If no SSDP address is specified, the default assumed will be 239.255.255.250:1900. If no port is specified, port 1900 is assumed as default.

111.14 Networking considerations

111.14.1 The UPnP Multicasts

The operating system must support multicasting on the selected network device. In certain cases, a multicasting route has to be set in the operating system routing table.

These configurations are highly dependent on the underlying operating system and beyond the scope of this specification.

111.15 Security

The UPnP specification is based on HTTP and uses plain text SOAP (XML) messages to control devices. For this reason, it does not provide any inherent security mechanisms. However, the UPnP specification is based on the exchange of XML files and not code. This means that at least worms and viruses cannot be implemented using the UPnP protocols.

However, a bundle registering a UPnP Device service is represented on the outside network and has the ability to communicate. The same is true for getting a UPnP Device service. It is therefore recommended that `ServicePermission[UPnPDevice|UPnPEventListener, REGISTER|GET]` be used sparingly and only for bundles that are trusted.

111.16 Changes

- Added a new interface that represents a Status Variable that is implemented locally. This is described in *State Variables* on page 255.
- Added a `UPnPException` class. This class can convey the UPnP Forum, work groups, and vendor defined errors. See *UPnPException* on page 266.
- Event Admin mapping added.

111.17 org.osgi.service.upnp

The OSGi UPnP API Package. Specification Version 1.1.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.service.upnp; version=1.1

111.17.1 Summary

- `UPnPAction` - A UPnP action. [p.260]
- `UPnPDevice` - Represents a UPnP device. [p.262]
- `UPnPEventListener` - UPnP Events are mapped and delivered to applications according to the OSGi whiteboard model. [p.265]
- `UPnPException` - There are several defined error situations describing UPnP problems while a control point invokes actions to UPnPDevices. [p.266]
- `UPnPIcon` - A UPnP icon representation. [p.267]
- `UPnPLocalStateVariable` - A local UPnP state variable which allows the value of the state variable to be queried. [p.268]
- `UPnPService` - A representation of a UPnP Service. [p.268]
- `UPnPStateVariable` - The meta-information of a UPnP state variable as declared in the device's service state table (SST). [p.270]

111.17.2 public interface UPnPAction

A UPnP action. Each UPnP service contains zero or more actions. Each action may have zero or more UPnP state variables as arguments.

111.17.2.1 public String[] getInputArgumentNames()

- Lists all input arguments for this action.

Each action may have zero or more input arguments.

Returns Array of input argument names or null if no input arguments.

See Also UPnPStateVariable[p.270]

111.17.2.2 public String getName()

- Returns the action name. The action name corresponds to the name field in the actionList of the service description.

- For standard actions defined by a UPnP Forum working committee, action names must not begin with X_ nor A_.
- For non-standard actions specified by a UPnP vendor and added to a standard service, action names must begin with X_.

Returns Name of action, must not contain a hyphen character or a hash character

111.17.2.3 public String[] getOutputArgumentNames()

- List all output arguments for this action.

Returns Array of output argument names or null if there are no output arguments.

See Also UPnPStateVariable[p.270]

111.17.2.4 public String getReturnArgumentName()

- Returns the name of the designated return argument.

One of the output arguments can be flagged as a designated return argument.

Returns The name of the designated return argument or null if none is marked.

111.17.2.5 public UPnPStateVariable getStateVariable(String argumentName)

argumentName The name of the UPnP action argument.

- Finds the state variable associated with an argument name. Helps to resolve the association of state variables with argument names in UPnP actions.

Returns State variable associated with the named argument or null if there is no such argument.

See Also UPnPStateVariable[p.270]

111.17.2.6 public Dictionary invoke(Dictionary args) throws Exception

args A Dictionary of arguments. Must contain the correct set and type of arguments for this action. May be null if no input arguments exist.

- Invokes the action. The input and output arguments are both passed as Dictionary objects. Each entry in the Dictionary object has a String object as key representing the argument name and the value is the argument itself. The class of an argument value must be assignable from the class of the associated UPnP state variable. The input argument Dictionary object must contain exactly those arguments listed by getInputArguments method. The output argument Dictionary object will contain exactly those arguments listed by getOutputArguments method.

Returns A Dictionary with the output arguments. null if the action has no output arguments.

Throws UPnPException – A UPnP error has occurred.

Exception – The execution fails for some reason.

See Also UPnPStateVariable[p.270]

111.17.3 public interface UPnPDevice

Represents a UPnP device. For each UPnP root and embedded device, an object is registered with the framework under the UPnPDevice interface.

The relationship between a root device and its embedded devices can be deduced using the UPnPDevice.CHILDREN_UDN and UPnPDevice.PARENT_UDN service registration properties.

The values of the UPnP property names are defined by the UPnP Forum.

All values of the UPnP properties are obtained from the device using the device's default locale.

If an application wants to query for a set of localized property values, it has to use the method UPnPDevice.getDescriptions(String locale).

111.17.3.1 public static final String CHILDREN_UDN = "UPnP.device.childrenUDN"

The property key that must be set for all devices containing other embedded devices.

The value is an array of UDNs for each of the device's children (String[]). The array contains UDNs for the immediate descendants only.

If an embedded device in turn contains embedded devices, the latter are not included in the array.

The UPnP Specification does not encourage more than two levels of nesting.

The property is not set if the device does not contain embedded devices.

The property is of type String[]. Value is "UPnP.device.childrenUDN"

111.17.3.2 public static final String DEVICE_CATEGORY = "UPnP"

Constant for the value of the service property DEVICE_CATEGORY used for all UPnP devices. Value is "UPnP".

See Also org.osgi.service.device.Constants.DEVICE_CATEGORY

111.17.3.3 public static final String FRIENDLY_NAME = "UPnP.device.friendlyName"

Mandatory property key for a short user friendly version of the device name. The property value holds a String object with the user friendly name of the device. Value is "UPnP.device.friendlyName".

111.17.3.4 public static final String ID = "UPnP.device.UDN"

Property key for the Unique Device ID property. This property is an alias to UPnPDevice.UDN. It is merely provided for reasons of symmetry with the UPnPService.ID property. The value of the property is a String object of the Device UDN. The value of the key is "UPnP.device.UDN".

- 111.17.3.5** **public static final String MANUFACTURER = “UPnP.device.manufacturer”**
Mandatory property key for the device manufacturer’s property. The property value holds a String representation of the device manufacturer’s name. Value is “UPnP.device.manufacturer”.
- 111.17.3.6** **public static final String MANUFACTURER_URL = “UPnP.device.manufacturerURL”**
Optional property key for a URL to the device manufacturers Web site. The value of the property is a String object representing the URL. Value is “UPnP.device.manufacturerURL”.
- 111.17.3.7** **public static final int MATCH_GENERIC = 1**
Constant for the UPnP device match scale, indicating a generic match for the device. Value is 1.
- 111.17.3.8** **public static final int MATCH_MANUFACTURER_MODEL = 7**
Constant for the UPnP device match scale, indicating a match with the device model. Value is 7.
- 111.17.3.9** **public static final int MATCH_MANUFACTURER_MODEL_REVISION = 15**
Constant for the UPnP device match scale, indicating a match with the device revision. Value is 15.
- 111.17.3.10** **public static final int MATCH_MANUFACTURER_MODEL_REVISION_SERIAL = 31**
Constant for the UPnP device match scale, indicating a match with the device revision and the serial number. Value is 31.
- 111.17.3.11** **public static final int MATCH_TYPE = 3**
Constant for the UPnP device match scale, indicating a match with the device type. Value is 3.
- 111.17.3.12** **public static final String MODEL_DESCRIPTION = “UPnP.device.modelDescription”**
Optional (but recommended) property key for a String object with a long description of the device for the end user. The value is “UPnP.device.modelDescription”.
- 111.17.3.13** **public static final String MODEL_NAME = “UPnP.device.modelName”**
Mandatory property key for the device model name. The property value holds a String object giving more information about the device model. Value is “UPnP.device.modelName”.
- 111.17.3.14** **public static final String MODEL_NUMBER = “UPnP.device.modelNumber”**
Optional (but recommended) property key for a String class typed property holding the model number of the device. Value is “UPnP.device.modelNumber”.

111.17.3.15 public static final String MODEL_URL = "UPnP.device.modelURL"

Optional property key for a String typed property holding a string representing the URL to the Web site for this model. Value is "UPnP.device.modelURL".

111.17.3.16 public static final String PARENT_UDN = "UPnP.device.parentUDN"

The property key that must be set for all embedded devices. It contains the UDN of the parent device. The property is not set for root devices. The value is "UPnP.device.parentUDN".

111.17.3.17 public static final String PRESENTATION_URL = "UPnP.presentationURL"

Optional (but recommended) property key for a String typed property holding a string representing the URL to a device representation Web page. Value is "UPnP.presentationURL".

111.17.3.18 public static final String SERIAL_NUMBER = "UPnP.device.serialNumber"

Optional (but recommended) property key for a String typed property holding the serial number of the device. Value is "UPnP.device.serialNumber".

111.17.3.19 public static final String TYPE = "UPnP.device.type"

Property key for the UPnP Device Type property. Some standard property values are defined by the Universal Plug and Play Forum. The type string also includes a version number as defined in the UPnP specification. This property must be set.

For standard devices defined by a UPnP Forum working committee, this must consist of the following components in the given order separated by colons:

- urn
- schemas-upnp-org
- device
- a device type suffix
- an integer device version

For non-standard devices specified by UPnP vendors following components must be specified in the given order separated by colons:

- urn
- an ICANN domain name owned by the vendor
- device
- a device type suffix
- an integer device version

To allow for backward compatibility the UPnP driver must automatically generate additional Device Type property entries for smaller versions than the current one. If for example a device announces its type as version 3, then properties for versions 2 and 1 must be automatically generated.

In the case of exporting a UPnPDevice, the highest available version must be announced on the network.

Syntax Example: urn:schemas-upnp-org:device:deviceType:v

The value is "UPnP.device.type".

111.17.3.20 public static final String UDN = “UPnP.device.UDN”

Property key for the Unique Device Name (UDN) property. It is the unique identifier of an instance of a UPnPDevice. The value of the property is a String object of the Device UDN. Value of the key is “UPnP.device.UDN”. This property must be set.

111.17.3.21 public static final String UPC = “UPnP.device.UPC”

Optional property key for a String typed property holding the Universal Product Code (UPC) of the device. Value is “UPnP.device.UPC”.

111.17.3.22 public static final String UPNP_EXPORT = “UPnP.export”

The UPnP.export service property is a hint that marks a device to be picked up and exported by the UPnP Service. Imported devices do not have this property set. The registered property requires no value.

The UPNP_EXPORT string is “UPnP.export”.

111.17.3.23 public Dictionary getDescriptions(String locale)

locale A language tag as defined by RFC 1766 and maintained by ISO 639. Examples include “de”, “en” or “en-US”. The default locale of the device is specified by passing a null argument.

- Get a set of localized UPnP properties. The UPnP specification allows a device to present different device properties based on the client’s locale. The properties used to register the UPnPDevice service in the OSGi registry are based on the device’s default locale. To obtain a localized set of the properties, an application can use this method.

Not all properties might be available in all locales. This method does **not** substitute missing properties with their default locale versions.

Returns Dictionary mapping property name Strings to property value Strings

111.17.3.24 public UPnPIcon[] getIcons(String locale)

locale A language tag as defined by RFC 1766 and maintained by ISO 639. Examples include “de”, “en” or “en-US”. The default locale of the device is specified by passing a null argument.

- Lists all icons for this device in a given locale. The UPnP specification allows a device to present different icons based on the client’s locale.

Returns Array of icons or null if no icons are available.

111.17.3.25 public UPnPService getService(String serviceId)

serviceId The service id

- Locates a specific service by its service id.

Returns The requested service or null if not found.

111.17.3.26 public UPnPService[] getServices()

- Lists all services provided by this device.

Returns Array of services or null if no services are available.

111.17.4 public interface UPnPEventListener

UPnP Events are mapped and delivered to applications according to the OSGi whiteboard model. An application that wishes to be notified of events generated by a particular UPnP Device registers a service extending this interface.

The notification call from the UPnP Service to any UPnPEventListener object must be done asynchronous with respect to the originator (in a separate thread).

Upon registration of the UPnP Event Listener service with the Framework, the service is notified for each variable which it listens for with an initial event containing the current value of the variable. Subsequent notifications only happen on changes of the value of the variable.

A UPnP Event Listener service filter the events it receives. This event set is limited using a standard framework filter expression which is specified when the listener service is registered.

The filter is specified in a property named “upnp.filter” and has as a value an object of type `org.osgi.framework.Filter`.

When the Filter is evaluated, the following keywords are recognized as defined as literal constants in the `UPnPDevice` class.

The valid subset of properties for the registration of UPnP Event Listener services are:

- `UPnPDevice.TYPE`-- Which type of device to listen for events.
- `UPnPDevice.ID`-- The ID of a specific device to listen for events.
- `UPnPService.TYPE`-- The type of a specific service to listen for events.
- `UPnPService.ID`-- The ID of a specific service to listen for events.

111.17.4.1 public static final String UPNP_FILTER = “upnp.filter”

Key for a service property having a value that is an object of type `org.osgi.framework.Filter` and that is used to limit received events.

111.17.4.2 public void notifyUPnPEvent(String deviceId, String serviceId, Dictionary events)

deviceId ID of the device sending the events

serviceId ID of the service sending the events

events Dictionary object containing the new values for the state variables that have changed.

- Callback method that is invoked for received events. The events are collected in a Dictionary object. Each entry has a String key representing the event name (= state variable name) and the new value of the state variable. The class of the value object must match the class specified by the UPnP State Variable associated with the event. This method must be called asynchronously

111.17.5 **public class UPnPException** **extends Exception**

There are several defined error situations describing UPnP problems while a control point invokes actions to UPnPDevices.

Since 1.1

111.17.5.1 **public static final int DEVICE_INTERNAL_ERROR = 501**

The invoked action failed during execution.

111.17.5.2 **public static final int INVALID_ACTION = 401**

No Action found by that name at this service.

111.17.5.3 **public static final int INVALID_ARGS = 402**

Not enough arguments, too many arguments with a specific name, or one of more of the arguments are of the wrong type.

111.17.5.4 **public static final int INVALID_SEQUENCE_NUMBER = 403**

The different end-points are no longer in synchronization.

111.17.5.5 **public static final int INVALID_VARIABLE = 404**

Refers to a non existing variable.

111.17.5.6 **public UPnPException(int errorCode, String errordesc)**

errorCode errorCode which defined UPnP Device Architecture V1.0.

errordesc errorDescription which explain the type of problem.

- This constructor creates a UPnPException on the specified error code and error description.

111.17.5.7 **public int getUPnPError_Code()**

- Returns the UPnPError Code occurred by UPnPDevices during invocation.

Returns The UPnPError Code defined by a UPnP Forum working committee or specified by a UPnP vendor.

111.17.6 **public interface UPnPIcon**

A UPnP icon representation. Each UPnP device can contain zero or more icons.

111.17.6.1 **public int getDepth()**

- Returns the color depth of the icon in bits.

Returns The color depth in bits. If the actual color depth of the icon is unknown, -1 is returned.

111.17.6.2 **public int getHeight()**

- Returns the height of the icon in pixels. If the actual height of the icon is unknown, -1 is returned.

Returns The height in pixels, or -1 if unknown.

111.17.6.3 `public InputStream getInputStream() throws IOException`

- Returns an InputStream object for the icon data. The InputStream object provides a way for a client to read the actual icon graphics data. The number of bytes available from this InputStream object can be determined via the `getSize()` method. The format of the data encoded can be determined by the MIME type available via the `getMimeType()` method.

Returns An InputStream to read the icon graphics data from.

Throws IOException – If the InputStream cannot be returned.

See Also UPnPIcon.`getMimeType()` [p.268]

111.17.6.4 `public String getMimeType()`

- Returns the MIME type of the icon. This method returns the format in which the icon graphics, read from the InputStream object obtained by the `getInputStream()` method, is encoded.

The format of the returned string is in accordance to RFC2046. A list of valid MIME types is maintained by the IANA (<http://www.iana.org/assignments/media-types/>).

Typical values returned include: “image/jpeg” or “image/gif”

Returns The MIME type of the encoded icon.

111.17.6.5 `public int getSize()`

- Returns the size of the icon in bytes. This method returns the number of bytes of the icon available to read from the InputStream object obtained by the `getInputStream()` method. If the actual size can not be determined, -1 is returned.

Returns The icon size in bytes, or -1 if the size is unknown.

111.17.6.6 `public int getWidth()`

- Returns the width of the icon in pixels. If the actual width of the icon is unknown, -1 is returned.

Returns The width in pixels, or -1 if unknown.

**111.17.7 `public interface UPnPLocalStateVariable
extends UPnPStateVariable`**

A local UPnP state variable which allows the value of the state variable to be queried.

Since 1.1

111.17.7.1 `public Object getCurrentValue()`

- This method will keep the current values of UPnPStateVariables of a UPnP-Device whenever UPnPStateVariable’s value is changed, this method must be called.

Returns Object current value of UPnPStateVariable. if the current value is initialized with the default value defined UPnP service description.

111.17.8 public interface UPnPService

A representation of a UPnP Service. Each UPnP device contains zero or more services. The UPnP description for a service defines actions, their arguments, and event characteristics.

111.17.8.1 public static final String ID = "UPnP.service.id"

Property key for the optional service id. The service id property is used when registering UPnP Device services or UPnP Event Listener services. The value of the property contains a String array (String[]) of service ids. A UPnP Device service can thus announce what service ids it contains. A UPnP Event Listener service can announce for what UPnP service ids it wants notifications. A service id does **not** have to be universally unique. It must be unique only within a device. A null value is a wildcard, matching **all** services. The value is "UPnP.service.id".

111.17.8.2 public static final String TYPE = "UPnP.service.type"

Property key for the optional service type uri. The service type property is used when registering UPnP Device services and UPnP Event Listener services. The property contains a String array (String[]) of service types. A UPnP Device service can thus announce what types of services it contains. A UPnP Event Listener service can announce for what type of UPnP services it wants notifications. The service version is encoded in the type string as specified in the UPnP specification. A null value is a wildcard, matching **all** service types. Value is "UPnP.service.type".

See Also UPnPService.getType() [p.270]

111.17.8.3 public UPnPAction getAction(String name)

name Name of action. Must not contain hyphen or hash characters. Should be <32 characters.

- Locates a specific action by name. Looks up an action by its name.

Returns The requested action or null if no action is found.

111.17.8.4 public UPnPAction[] getActions()

- Lists all actions provided by this service.

Returns Array of actions (UPnPAction[]) or null if no actions are defined for this service.

111.17.8.5 public String getId()

- Returns the serviceId field in the UPnP service description.

For standard services defined by a UPnP Forum working committee, the serviceId must contain the following components in the indicated order:

- urn:upnp-org:serviceId:
- service ID suffix

Example: urn:upnp-org:serviceId:serviceID.

Note that upnp-org is used instead of schemas-upnp-org in this example because an XML schema is not defined for each serviceId.

For non-standard services specified by UPnP vendors, the serviceId must contain the following components in the indicated order:

- urn:
- ICANN domain name owned by the vendor
- :serviceId:
- service ID suffix

Example: urn:domain-name:serviceId:serviceID.

Returns The service ID suffix defined by a UPnP Forum working committee or specified by a UPnP vendor. Must be <= 64 characters. Single URI.

111.17.8.6 public UPnPStateVariable getStateVariable(String name)

name Name of the State Variable

- Gets a UPnPStateVariable objects provided by this service by name

Returns State variable or null if no such state variable exists for this service.

111.17.8.7 public UPnPStateVariable[] getStateVariables()

- Lists all UPnPStateVariable objects provided by this service.

Returns Array of state variables or null if none are defined for this service.

111.17.8.8 public String getType()

- Returns the serviceType field in the UPnP service description.

For standard services defined by a UPnP Forum working committee, the serviceType must contain the following components in the indicated order:

- urn:schemas-upnp-org:service:
- service type suffix:
- integer service version

Example: urn:schemas-upnp-org:service:serviceType:v.

For non-standard services specified by UPnP vendors, the serviceType must contain the following components in the indicated order:

- urn:
- ICANN domain name owned by the vendor
- :service:
- service type suffix:
- integer service version

Example: urn:domain-name:service:serviceType:v.

Returns The service type suffix defined by a UPnP Forum working committee or specified by a UPnP vendor. Must be <= 64 characters, not including the version suffix and separating colon. Single URI.

111.17.8.9 public String getVersion()

- Returns the version suffix encoded in the serviceType field in the UPnP service description.

Returns The integer service version defined by a UPnP Forum working committee or specified by a UPnP vendor.

111.17.9 public interface UPnPStateVariable

The meta-information of a UPnP state variable as declared in the device's service state table (SST).

Method calls to interact with a device (e.g. UPnPAction.invoke(...)) use this class to encapsulate meta information about the input and output arguments.

The actual values of the arguments are passed as Java objects. The mapping of types from UPnP data types to Java data types is described with the field definitions.

111.17.9.1 public static final String TYPE_BIN_BASE64 = "bin.base64"

MIME-style Base64 encoded binary BLOB.

Takes 3 Bytes, splits them into 4 parts, and maps each 6 bit piece to an octet. (3 octets are encoded as 4.) No limit on size.

Mapped to byte[] object. The Java byte array will hold the decoded content of the BLOB.

111.17.9.2 public static final String TYPE_BIN_HEX = "bin.hex"

Hexadecimal digits representing octets.

Treats each nibble as a hex digit and encodes as a separate Byte. (1 octet is encoded as 2.) No limit on size.

Mapped to byte[] object. The Java byte array will hold the decoded content of the BLOB.

111.17.9.3 public static final String TYPE_BOOLEAN = "boolean"

True or false.

Mapped to Boolean object.

111.17.9.4 public static final String TYPE_CHAR = "char"

Unicode string.

One character long.

Mapped to Character object.

111.17.9.5 public static final String TYPE_DATE = "date"

A calendar date.

Date in a subset of ISO 8601 format without time data.

See <http://www.w3.org/TR/xmlschema-2/#date> (<http://www.w3.org/TR/xmlschema-2/#date>).

Mapped to java.util.Date object. Always 00:00 hours.

111.17.9.6 public static final String TYPE_DATETIME = "dateTime"

A specific instant of time.

Date in ISO 8601 format with optional time but no time zone.

See <http://www.w3.org/TR/xmlschema-2/#dateTime> (<http://www.w3.org/TR/xmlschema-2/#dateTime>).

Mapped to java.util.Date object using default time zone.

111.17.9.7 public static final String TYPE_DATETIME_TZ = "dateTime.tz"

A specific instant of time.

Date in ISO 8601 format with optional time and optional time zone.

See <http://www.w3.org/TR/xmlschema-2/#dateTime> (<http://www.w3.org/TR/xmlschema-2/#dateTime>).

Mapped to java.util.Date object adjusted to default time zone.

111.17.9.8 public static final String TYPE_FIXED_14_4 = "fixed.14.4"

Same as r8 but no more than 14 digits to the left of the decimal point and no more than 4 to the right.

Mapped to Double object.

111.17.9.9 public static final String TYPE_FLOAT = "float"

Floating-point number.

Mantissa (left of the decimal) and/or exponent may have a leading sign.

Mantissa and/or exponent may have leading zeros. Decimal character in mantissa is a period, i.e., whole digits in mantissa separated from fractional digits by period. Mantissa separated from exponent by E. (No currency symbol.) (No grouping of digits in the mantissa, e.g., no commas.)

Mapped to Float object.

111.17.9.10 public static final String TYPE_I1 = "i1"

1 Byte int.

Mapped to Integer object.

111.17.9.11 public static final String TYPE_I2 = "i2"

2 Byte int.

Mapped to Integer object.

111.17.9.12 public static final String TYPE_I4 = "i4"

4 Byte int.

Must be between -2147483648 and 2147483647

Mapped to Integer object.

111.17.9.13 public static final String TYPE_INT = "int"

Integer number.

Mapped to Integer object.

111.17.9.14 public static final String TYPE_NUMBER = "number"

Same as r8.

Mapped to Double object.

111.17.9.15 public static final String TYPE_R4 = "r4"

4 Byte float.

Same format as float. Must be between 3.40282347E+38 to 1.17549435E-38.

Mapped to Float object.

111.17.9.16 public static final String TYPE_R8 = "r8"

8 Byte float.

Same format as float. Must be between -1.79769313486232E308 and -4.94065645841247E-324 for negative values, and between 4.94065645841247E-324 and 1.79769313486232E308 for positive values, i.e., IEEE 64-bit (8-Byte) double.

Mapped to Double object.

111.17.9.17 public static final String TYPE_STRING = "string"

Unicode string.

No limit on length.

Mapped to String object.

111.17.9.18 public static final String TYPE_TIME = "time"

An instant of time that recurs every day.

Time in a subset of ISO 8601 format with no date and no time zone.

See <http://www.w3.org/TR/xmlschema-2/#time> (<http://www.w3.org/TR/xmlschema-2/#dateTime>).

Mapped to Long. Converted to milliseconds since midnight.

111.17.9.19 public static final String TYPE_TIME_TZ = "time.tz"

An instant of time that recurs every day.

Time in a subset of ISO 8601 format with optional time zone but no date.

See <http://www.w3.org/TR/xmlschema-2/#time> (<http://www.w3.org/TR/xmlschema-2/#dateTime>).

Mapped to Long object. Converted to milliseconds since midnight and adjusted to default time zone, wrapping at 0 and 24*60*60*1000.

111.17.9.20 public static final String TYPE_UI1 = "ui1"

Unsigned 1 Byte int.

Mapped to an Integer object.

111.17.9.21 public static final String TYPE_UI2 = "ui2"

Unsigned 2 Byte int.

Mapped to Integer object.

111.17.9.22	public static final String TYPE_UI4 = "ui4" Unsigned 4 Byte int. Mapped to Long object.																		
111.17.9.23	public static final String TYPE_URI = "uri" Universal Resource Identifier. Mapped to String object.																		
111.17.9.24	public static final String TYPE_UUID = "uuid" Universally Unique ID. Hexadecimal digits representing octets. Optional embedded hyphens are ignored. Mapped to String object.																		
111.17.9.25	public String[] getAllowedValues() <div>□ Returns the allowed values, if defined. Allowed values can be defined only for String types.</div> <div>Returns The allowed values or null if not defined. Should be less than 32 characters.</div>																		
111.17.9.26	public Object getDefaultValue() <div>□ Returns the default value, if defined.</div> <div>Returns The default value or null if not defined. The type of the returned object can be determined by getJavaDataType.</div>																		
111.17.9.27	public Class getJavaDataType() <div>□ Returns the Java class associated with the UPnP data type of this state variable.</div> <div>Mapping between the UPnP data types and Java classes is performed according to the schema mentioned above.</div> <table><tr><td>Integer</td><td>ui1, ui2, i1, i2, i4, int</td></tr><tr><td>Long</td><td>ui4, time, time.tz</td></tr><tr><td>Float</td><td>r4, float</td></tr><tr><td>Double</td><td>r8, number, fixed.14.4</td></tr><tr><td>Character</td><td>char</td></tr><tr><td>String</td><td>string, uri, uuid</td></tr><tr><td>Date</td><td>date, dateTime, dateTime.tz</td></tr><tr><td>Boolean</td><td>boolean</td></tr><tr><td>byte[]</td><td>bin.base64, bin.hex</td></tr></table> <div>Returns A class object corresponding to the Java type of this argument.</div>	Integer	ui1, ui2, i1, i2, i4, int	Long	ui4, time, time.tz	Float	r4, float	Double	r8, number, fixed.14.4	Character	char	String	string, uri, uuid	Date	date, dateTime, dateTime.tz	Boolean	boolean	byte[]	bin.base64, bin.hex
Integer	ui1, ui2, i1, i2, i4, int																		
Long	ui4, time, time.tz																		
Float	r4, float																		
Double	r8, number, fixed.14.4																		
Character	char																		
String	string, uri, uuid																		
Date	date, dateTime, dateTime.tz																		
Boolean	boolean																		
byte[]	bin.base64, bin.hex																		
111.17.9.28	public Number getMaximum() <div>□ Returns the maximum value, if defined. Maximum values can only be defined for numeric types.</div> <div>Returns The maximum value or null if not defined.</div>																		

111.17.9.29 public Number getMinimum()

- ❑ Returns the minimum value, if defined. Minimum values can only be defined for numeric types.

Returns The minimum value or null if not defined.

111.17.9.30 public String getName()

- ❑ Returns the variable name.
 - All standard variables defined by a UPnP Forum working committee must not begin with X_ nor A_.
 - All non-standard variables specified by a UPnP vendor and added to a standard service must begin with X_.

Returns Name of state variable. Must not contain a hyphen character nor a hash character. Should be <32 characters.

111.17.9.31 public Number getStep()

- ❑ Returns the size of an increment operation, if defined. Step sizes can be defined only for numeric types.

Returns The increment size or null if not defined.

111.17.9.32 public String getUPnPDataType()

- ❑ Returns the UPnP type of this state variable. Valid types are defined as constants.

Returns The UPnP data type of this state variable, as defined in above constants.

111.17.9.33 public boolean sendsEvents()

- ❑ Tells if this StateVariable can be used as an event source. If the StateVariable is eventable, an event listener service can be registered to be notified when changes to the variable appear.

Returns true if the StateVariable generates events, false otherwise.

111.18 References

- [45] *UPnP Device Architecture*
http://www.upnp.org/download/UPnPDA10_20000613.htm
- [46] *UPnP Forum*
<http://www.upnp.org>
- [47] *Simple Object Access Protocol, SOAP*
<http://www.w3.org/TR/SOAP>
- [48] *General Event Notification Architecture, GENA*
<http://www.upnp.org/download/draft-cohen-gena-client-01.txt>
- [49] *Simple Service Discovery Protocol, SSDP*
http://www.upnp.org/download/draft_cai_ssdp_v1_03.txt
- [50] *XML Schema*
<http://www.w3.org/TR/xmlschema-2>

- [51] *ISO 8601 Date And Time formats*
www.iso.ch

112 Declarative Services Specification

Version 1.0

112.1 Introduction

The OSGi Framework contains a procedural service model which provides a publish/find/bind model for using *services*. This model is elegant and powerful, it enables the building of applications out of bundles that communicate and collaborate using these services.

This specification addresses some of the complications that arise when the OSGi service model is used for larger systems and wider deployments, such as:

- *Startup Time* – The procedural service model requires a bundle to actively register and acquire its services. This is normally done at startup time, requiring all present bundles to be initialized with a Bundle Activator. In larger systems, this quickly results in unacceptably long startup times.
- *Memory Footprint* – A service registered with the Framework implies that the implementation, and related classes and objects, are loaded in memory. If the service is never used, this memory is unnecessarily occupied. The creation of a class loader may therefore cause significant overhead.
- *Complexity* – Service can come and go at any time. This dynamic behavior makes the service programming model more complex than more traditional models. This complexity negatively influences the adoption of the OSGi service model as well as the robustness and reliability of applications because these applications do not always handle the dynamicity correctly.

The *service component* model uses a declarative model for publishing, finding and binding to OSGi services. This model simplifies the task of authoring OSGi services by performing the work of registering the service and handling service dependencies. This minimizes the amount of code a programmer has to write; it also allows service components to be loaded only when they are needed. As a result, bundles need not provide a BundleActivator class to collaborate with others through the service registry.

From a system perspective, the service component model means reduced startup time and potentially a reduction of the memory footprint. From a programmer's point of view the service component model provides a simplified programming model.

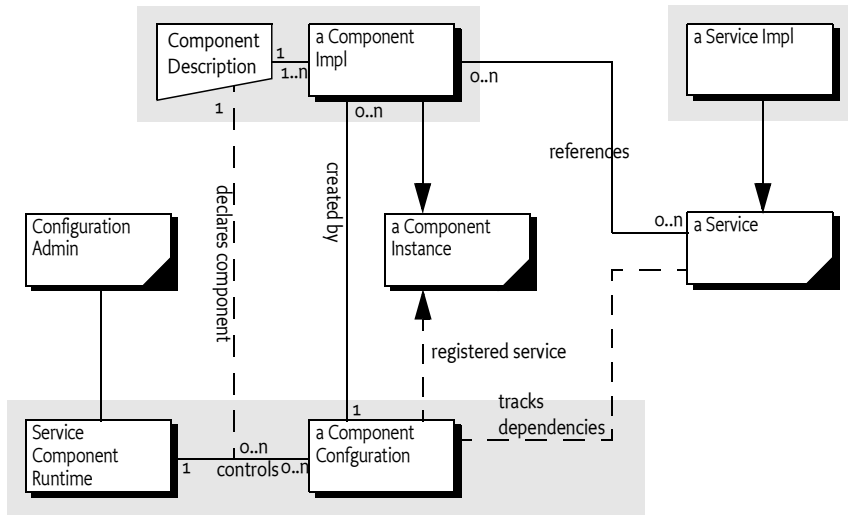
The Service Component model makes use of concepts described in [52] *Automating Service Dependency Management in a Service-Oriented Component Model*.

112.1.1**Essentials**

- *Backward Compatibility* – The service component model must operate seamlessly with the existing service model.
- *Size Constraints* – The service component model must not require memory and performance intensive subsystems. The model must also be applicable on resource constrained devices.
- *Delayed Activation* – The service component model must allow delayed activation of a service component. Delayed activation allows for delayed class loading and object creation until needed, thereby reducing the overall memory footprint.
- *Simplicity* – The programming model for using declarative services must be very simple and not require the programmer to learn a complicated API or XML sub-language.

112.1.2**Entities**

- *Service Component* – A service component contains a description that is interpreted at run time to create and dispose objects depending on the availability of other services, the need for such an object, and available configuration data. Such objects can optionally provide a service. This specification also uses the generic term *component* to refer to a service component.
- *Component Description* – The declaration of a service component. It is contained within an XML document in a bundle.
- *Component Properties* – A set of properties which can be specified by the component description, Configuration Admin service and from the component factory.
- *Component Configuration* – A component configuration represents a component description parameterized by component properties. It is the entity that tracks the component dependencies and manages a component instance. An activated component configuration has a component context.
- *Component Instance* – An instance of the component implementation class. A component instance is created when a component configuration is activated and discarded when the component configuration is deactivated. A component instance is associated with exactly one component configuration.
- *Delayed Component* – A component whose component configurations are activated when their service is requested.
- *Immediate Component* – A component whose component configurations are activated immediately upon becoming satisfied.
- *Factory Component* – A component whose component configurations are created and activated through the component's component factory.
- *Reference* – A specified dependency of a component on a set of target services.
- *Service Component Runtime (SCR)* – The actor that manages the components and their life cycle.
- *Target Services* – The set of services that is defined by the reference interface and target property filter.
- *Bound Services* – The set of target services that are bound to a component configuration.

Figure 44 Service Component Runtime, *org.osgi.service.component* package

112.1.3 Synopsis

The Service Component Runtime reads component descriptions from started bundles. These descriptions are in the form of XML documents which define a set of components for a bundle. A component can refer to a number of services that must be available before a component configuration becomes satisfied. These dependencies are defined in the descriptions and the specific target services can be influenced by configuration information in the Configuration Admin service. After a component configuration becomes satisfied, a number of different scenarios can take place depending on the component type:

- *Immediate Component* – The component configuration of an immediate component must be activated immediately after becoming satisfied. Immediate components may provide a service.
- *Delayed Component* – When a component configuration of a delayed component becomes satisfied, SCR will register the service specified by the service element without activating the component configuration. If this service is requested, SCR must activate the component configuration creating an instance of the component implementation class that will be returned as the service object. If the servicefactory attribute of the service element is true, then, for each distinct bundle that requests the service, a different component configuration is created and activated and a new instance of the component implementation class is returned as the service object.
- *Factory Component* – If a component's description specifies the factory attribute of the component element, SCR will register a Component Factory service. This service allows client bundles to create and activate multiple component configurations and dispose of them. If the component's description also specifies a service element, then as each component configuration is activated, SCR will register it as a service.

112.1.4**Readers**

- *Architects* – The chapter, *Components* on page 280, gives a comprehensive introduction to the capabilities of the component model. It explains the model with a number of examples. The section about *Component Life Cycle* on page 294 provides some deeper insight in the life cycle of components.
- *Service Programmers* – Service programmers should read *Components* on page 280. This chapter should suffice for the most common cases. For the more advanced possibilities, they should consult *Component Description* on page 289 for the details of the XML grammar for component descriptions.
- *Deployers* – Deployers should consult *Deployment* on page 302.

112.2**Components**

A component is a normal Java class contained within a bundle. The distinguishing aspect of a component is that it is *declared* in an XML document. Component configurations are activated and deactivated under the full control of SCR. SCR bases its decisions on the information in the component's description. This information consists of basic component information like the name and type, optional services that are implemented by the component, and *references*. References are dependencies that the component has on other services.

SCR must *activate* a component configuration when the component is enabled and the component configuration is satisfied and a component configuration is needed. During the life time of a component configuration, SCR can notify the component of changes in its bound references.

SCR will *deactivate* a previously activated component configuration when the component becomes disabled, the component configuration becomes unsatisfied, or the component configuration is no longer needed.

If an activated component configuration's configuration properties change, SCR must deactivate the component configuration and then attempt to reactivate the component configuration using the new configuration information.

112.2.1**Declaring a Component**

A component requires the following artifacts in the bundle:

- An XML document that contains the component description.
- The Service-Component manifest header which names the XML documents that contain the component descriptions.
- An implementation class that is specified in the component description.

The elements in the component's description are defined in *Component Description* on page 289. The XML grammar for the component declaration is defined by the XML Schema, see *Component Description Schema* on page 304.

112.2.2 Immediate Component

An *immediate component* is activated as soon as its dependencies are satisfied. If an immediate component has no dependencies, it is activated immediately. A component is an immediate component if it is not a factory component and either does not specify a service or specifies a service and the immediate attribute of the component element set to true. If an immediate component configuration is satisfied and specifies a service, SCR must register the component configuration as a service in the service registry and then activate the component configuration.

For example, the bundle entry `/OSGI-INF/activator.xml` contains:

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.activator">
  <implementation class="com.acme.Activator"/>
</component>
```

The manifest header `Service-Component` must also be specified in the bundle manifest. For example:

Service-Component: OSGI-INF/activator.xml

An example class for this component could look like:

```
public class Activator {
    public Activator() {...}
    protected void activate(ComponentContext ctxt) {...}
    protected void deactivate(ComponentContext ctxt) {...}
}
```

This example component is virtually identical to a Bundle Activator. It has no references to other services so it will be satisfied immediately. It publishes no service so SCR will activate a component configuration immediately.

The `activate` method is called when SCR activates the component configuration and the `deactivate` method is called when SCR deactivates the component configuration. If the `activate` method throws an Exception, then the component configuration is not activated and will be discarded.

112.2.3 Delayed Component

A *delayed component* specifies a service, is not specified to be a factory component and does not have the immediate attribute of the component element set to true. If a delayed component configuration is satisfied, SCR must register the component configuration as a service in the service registry but the activation of the component configuration is delayed until the registered service is requested. The registered service of a delayed component look like on ordinarily registered service but does not incur the overhead of an ordinarily registered service that require a service's bundle to be initialized to register the service.

For example, a bundle needs to see events of a specific topic. The Event Admin uses the white board pattern, receiving the events is therefore as simple as registering a Event Handler service. The example XML for the delayed component looks like:

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.handler">
  <implementation class="com.acme.HandlerImpl"/>
  <property name="event.topics" value="some/topic"/>
  <service>
    <provide interface=
      "org.osgi.service.event.EventHandler"/>
  </service>
</component>
```

The associated component class looks like:

```
public class HandlerImpl implements EventHandler {
    public void handleEvent(Event evt ) {
        ...
    }
}
```

The component configuration will only be activated once the Event Admin service requires the service because it has an event to deliver on the topic to which the component subscribed.

112.2.4 Factory Component

Certain software patterns require the creation of component configurations on demand. For example, a component could represent an application that can be launched multiple times and each application instance can then quit independently. Such a pattern requires a factory that creates the instances. This pattern is supported with a *factory component*. A factory component is used if the factory attribute of the component element is set to a *factory identifier*. This identifier can be used by a bundle to associate the factory with externally defined information.

SCR must register a Component Factory service on behalf of the component as soon as the component factory is satisfied. The service properties must be:

- `component.name` – The name of the component.
- `component.factory` – The factory identifier.

New configurations of the component can be created and activated by calling the `newInstance` method on this Component Factory service. The `newInstance(Dictionary)` method has a Dictionary object as argument. This Dictionary object is merged with the component properties as described in *Component Properties* on page 301. If the component specifies a service, then the service is registered after the created component configuration is satisfied with the component properties as service properties. Then the component configuration is activated.

For example, a component can provide a connection to a USB device. Such a connection should normally not be shared and should be created each time such a service is needed. The component description to implement this pattern looks like:

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.factory" factory="example.factory">
  <implementation class="com.acme.USBConnectionImpl"/>
</component>
```

The component class looks like:

```
public class USBConnectionImpl implements USBConnection {
    protected void activate(ComponentContext ctxt) {
        ... // ctxt provides access to properties
    }
}
```

A factory component can be associated with a service. In that case, such a service is registered for each component configuration. For example, the previous example could provide a USB Connection service.

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.factory" factory="usb.connection">
    <implementation class="com.acme.USBConnectionImpl"/>
    <service>
        <provide interface="com.acme.USBConnection"/>
    </service>
</component>
```

The associated component class looks like:

```
public class USBConnectionImpl implements USBConnection {
    protected void activate(ComponentContext ctxt) {...}
    public void connect() { ... }
    ...
    public void close() { ... }
}
```

A new service will be registered each time a new component configuration is created and activated with the `newInstance` method. This allows a bundle other than the one creating the component configuration to utilize the service. If the component configuration is deactivated, the service must be unregistered.

112.3 References to Services

Most bundles will require access to other services from the service registry. The dynamics of the service registry require care and attention of the programmer because referenced services, once acquired, could be unregistered at any moment. The component model simplifies the handling of these service dependencies significantly.

The services that are selected by a reference are called the *target services*. These are the services selected by the `BundleContext.getServiceReferences` method where the first argument is the reference's interface and the second argument is the reference's target property, which must be a valid filter.

A component configuration becomes *satisfied* when each specified reference is satisfied. A reference is *satisfied* if it specifies optional cardinality or when the target services contains at least one member. An activated component configuration that becomes *unsatisfied* must be deactivated.

During the activation of a component configuration, SCR must bind some or all of the target services of a reference to the component configuration. Any target service that is bound to the component configuration is called a *bound service*. See *Binding Services* on page 298.

112.3.1 Accessing Services

A component instance must be able to use the services that are referenced by the component configuration, that is, the bound services of the references. There are two strategies for a component instance to acquire these bound services:

- *Event strategy* – SCR calls a method on the component instance when a service becomes bound and another method when a service becomes unbound. These methods are the bind and unbind methods specified by the reference. The event strategy is useful if the component needs to be notified of changes to the bound services for a dynamic reference.
- *Lookup strategy* – A component instance can use one of the `locateService` methods of [ComponentContext](#) to locate a bound service. These methods take the name of the reference as a parameter. If the reference has a dynamic policy, it is important to not store the returned service object(s) but look it up every time it is needed.

A component may use either or both strategies to access bound services.

When using the event strategy, the bind and unbind methods will be called by SCR using reflection and must be protected or public methods. These methods should not be public methods so that they do not appear as public methods on the component instance if it is registered as a service.

The bind and unbind methods must take a single object as an argument. They have the following prototype:

```
protected void <method-name>(<parameter-type>);
```

The type of the parameter of the bind or unbind method determines the value passed to the method. If the type of the parameter is `org.osgi.framework.ServiceReference` then a Service Reference to the bound service will be passed to the method. This Service Reference may later be passed to the [locateService\(String,ServiceReference\)](#) method to obtain the actual service object. This approach is useful when the service properties need to be examined before accessing the service object. It also allows for the delayed activation of bound services when using the event strategy.

If the parameter is of another type, the service object of the bound service is passed to the method. The method's parameter type must be assignable from the type specified by the reference's interface attribute. That is, the service object of the bound service must be castable to the method's parameter type.

The methods must be called once for each bound service. This implies that if the reference has multiple cardinality, then the methods may be called multiple times.

When searching for the bind or unbind method to call, SCR must look through the component implementation class hierarchy. The declared methods of each class are searched for a method with the specified name that takes a single parameter. The method is searched for using the following priority:

- 1 The method's parameter type is `org.osgi.framework.ServiceReference`.
- 2 The method's parameter type is the type specified by the reference's interface attribute.
- 3 The method's parameter type is assignable from the type specified by the reference's interface attribute. If multiple methods match this rule, this implies the method name is overloaded and SCR may choose any of the methods to call.

If no suitable method is found, the search is repeated on the superclass. Once a suitable method is found, if it is declared protected or public, SCR will call the method. If the method is not found or the found method is not declared protected or public, SCR must log an error message with the Log Service, if present, and ignore the method.

When the service object for a bound service is first provided to a component instance, that is passed to a bind or unbind method or returned by a locate service method, SCR must get the service object from the OSGi Framework's service registry using the `getService` method on the component's Bundle Context. If the service object for a bound service has been obtained and the service becomes unbound, SCR must unget the service object using the `ungetService` method on the component's Bundle Context and discard all references to the service object.

For example, a component requires the Log Service and uses the lookup strategy. The reference is declared without any bind and unbind methods:

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.listen">
  <implementation class="com.acme.LogLookupImpl"/>
  <reference name="LOG"
    interface="org.osgi.service.log.LogService"/>
</component>
```

The component implementation class must now lookup the service. This looks like:

```
public class LogLookupImpl {
    protected void activate(ComponentContext ctxt) {
        LogService log = (LogService)
            ctxt.locateService("LOG");
        log.log(LogService.LOG_INFO, "Hello Components!");
    }
}
```

Alternatively, the component could use the event strategy and ask to be notified with the Log Service by declaring bind and unbind methods.

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.listen">
  <implementation class="com.acme.LogEventImpl"/>
  <reference name="LOG"
```

```

        interface="org.osgi.service.log.LogService"
        bind="setLog"
        unbind="unsetLog"
    />
</component>

```

The component implementation class looks like:

```

public class LogEventImpl {
    LogService    log;
    protected void setLog( LogService l ) { log = l; }
    protected void unsetLog( LogService l ) { log = null; }
    protected void activate(ComponentContext ctxt) {
        log.log(LogService.LOG_INFO, "Hello Components!");
    }
}

```

112.3.2 Reference Cardinality

A component implementation is always written with a certain *cardinality* in mind. The cardinality represents two important concepts:

- *Multiplicity* – Does the component implementation assume a single service or does it explicitly handle multiple occurrences? For example, when a component uses the Log Service, it only needs to bind to one Log Service to function correctly. Alternatively, when the Configuration Admin uses the Configuration Listener services it needs to bind to all target services present in the service registry to dispatch its events correctly.
- *Optionality* – Can the component function without any bound service present? Some components can still perform useful tasks even when no target service is available, other components must bind to at least one target service before they can be useful. For example, the Configuration Admin in the previous example must still provide its functionality even if there are no Configuration Listener services present. Alternatively, an application that solely presents a Servlet page has little to do when the Http Service is not present, it should therefore use a reference with a mandatory cardinality.

The cardinality is expressed with the following syntax:

```

cardinality ::= optionality '..' multiplicity
optionality ::= '0' | '1'
multiplicity ::= '1' | 'n'

```

A reference is *satisfied* if the number of target services is equal to or more than the optionality. The multiplicity is irrelevant for the satisfaction of the reference. The multiplicity only specifies if the component implementation is written to handle being bound to multiple services (n) or requires SCR to select and bind to a single service (1).

The cardinality for a reference can be specified as one of four choices:

- 0..1 – Optional and unary.
- 1..1 – Mandatory and unary (Default).
- 0..n – Optional and multiple.
- 1..n – Mandatory and multiple.

When a satisfied component configuration is activated, there must be at most one bound service for each reference with a unary cardinality and at least one bound service for each reference with a mandatory cardinality. If the cardinality constraints cannot be maintained after a component configuration is activated, that is the reference becomes unsatisfied, the component configuration must be deactivated. If the reference has a unary cardinality and there is more than one target service for the reference, then the bound service must be the target service with the highest service ranking as specified by the `service.ranking` property. If there are multiple target services with the same service ranking, then the bound service must be the target service with the highest service ranking and the lowest service ID as specified by the `service.id` property.

For example, a component wants to register a resource with all Http Services that are available. Such a scenario has the cardinality of `0..n`. The code must be prepared to handle multiple calls to the `bind` method for each Http Service in such a case. In this example, the code uses the `registerResources` method to register a directory for external access.

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.listen">
  <implementation class="com.acme.HttpResourceImpl"/>
  <reference name="LOG"
    interface="org.osgi.service.http.HttpService"
    cardinality="0..n"
    bind="setPage"
    unbind="unsetPage"
  />
</component>

public class HttpResourceImpl {
    protected void setPage(HttpService http) {
        http.registerResources("/scr", "scr", null );
    }
    protected void unsetPage(HttpService http) {
        http.unregister("/src");
    }
}
```

112.3.3

Reference Policy

Once all the references of a component are satisfied, a component configuration can be activated and therefore bound to target services. However, the dynamic nature of the OSGi service registry makes it likely that services are registered, modified and unregistered after target services are bound. These changes in the service registry could make one or more bound services no longer a target service thereby making obsolete any object references that the component has to these service objects. Components therefore must specify a *policy* how to handle these changes in the set of bound services.

The *static policy* is the most simple policy and is the default policy. A component instance never sees any of the dynamics. Component configurations are deactivated before any bound service for a reference having a static policy becomes unavailable. If a target service is available to replace the bound

service which became unavailable, the component configuration must be reactivated and bound to the replacement service. A reference with a static policy is called a *static reference*.

The static policy can be very expensive if it depends on services that frequently unregister and re-register or if the cost of activating and deactivating a component configuration is high. Static policy is usually also not applicable if the cardinality specifies multiple bound services.

The *dynamic policy* is slightly more complex since the component implementation must properly handle changes in the set of bound services. With the dynamic policy, SCR can change the set of bound services without deactivating a component configuration. If the component uses the event strategy to access services, then the component instance will be notified of changes in the set of bound services by calls to the bind and unbind methods. A reference with a dynamic policy is called a *dynamic reference*.

The previous example with the registering of a resource directory used a static policy. This implied that the component configurations are deactivated when there is a change in the bound set of Http Services. The code in the example can be seen to easily handle the dynamics of Http Services that come and go. The component description can therefore be updated to:

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.listen">
  <implementation class="com.acme.HttpResourceImpl"/>
  <reference name="LOG"
    interface="org.osgi.service.http.HttpService"
    cardinality="0..n"
    policy="dynamic"
    bind="setPage"
    unbind="unsetPage"
  />
</component>
```

The code is identical to the previous example.

112.3.4 Selecting Target Services

The target services for a reference are constrained by the reference's interface name and target property. By specifying a filter in the target property, the programmer and deployer can constrain the set of services that should be part of the target services.

For example, a component wants to track all Component Factory services that have a factory identification of acme.application. The following component description shows how this can be done.

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.listen">
  <implementation class="com.acme.FactoryTracker"/>
  <reference name="FACTORY"
    interface=
      "org.osgi.service.component.ComponentFactory"
```

```

        target=" (component. factory=acme. application) "
    />
</component>

```

Since the target filter is manifested as a component property, called the *target property*, the deployer can modify the target filter by establishing a configuration for the component which sets the value of the target property. See *Component Properties* on page 301 for more information.

112.3.5

Circular References

It is possible for a set of component descriptions to create a circular dependency. For example, if component A references a service provided by component B and component B references a service provided by component A then a component configuration of one component cannot be satisfied without accessing a “partially” activated component instance of the other component. SCR must ensure that a component instance is never accessible to another component instance or as a service until it has been fully activated, that is it has returned from its activate method if it has one.

Circular references must be detected by SCR when it attempts to satisfy component configurations and SCR must fail to satisfy the references involved in the cycle and log an error message with the Log Service, if present. However, if one of the references in the cycle has optional cardinality SCR must break the cycle. The reference with the optional cardinality can be satisfied and bound to zero target services. Therefore the cycle is broken and the other references may be satisfied.

112.4

Component Description

Component descriptions are defined in XML documents contained in a bundle and any attached fragments.

If SCR detects an error when processing a component description, it must log an error message with the Log Service, if present, and ignore the component description. Errors can include XML parsing errors and ill-formed component descriptions.

112.4.1

Service Component Header

XML documents containing component descriptions must be specified by the Service-Component header in the manifest. The value of the header is a comma separated list of XML entries within the bundle.

```
Service-Component ::= path ( ' , ' path ) *
```

A Service-Component manifest header specified in a fragment is ignored by SCR. However, XML documents referenced by a bundle’s Service-Component manifest header may be contained in attached fragments.

SCR must process each XML document specified in this header. If an XML document specified by the header cannot be located in the bundle and its attached fragments, SCR must log an error message with the Log Service, if present, and continue.

112.4.2 XML Document

A component description must be stored in a UTF-8 encoded bundle entry. The name space for component descriptions is:

`http://www.osgi.org/xmlns/scr/v1.0.0`

The recommended prefix for this name space is `scr`. This prefix is used in this specification. XML documents containing component descriptions may contain a single, root component element or one or more component elements embedded in a larger document. Use of the name space is optional if the document only contains a root component element. In this case, the `scr` name space is assumed. Otherwise the name space must be used.

SCR must parse all component elements in the `scr` name space. Elements not in this name space must be ignored. Ignoring elements that are not recognized allows component descriptions to be embedded in any XML document. For example, an entry can provide additional information about components. These additional elements are parsed by another sub-system.

See *Component Description Schema* on page 304 for component description schema.

112.4.3 Component Element

The component element specifies the component description. The following text defines the structure of the XML grammar using a form that is similar to the normal grammar used in OSGi specifications. In this case the grammar should be mapped to XML elements:

```
<component> ::= <implementation>
               <properties> *
               <service> ?
               <reference> *
```

The component element has the following attributes:

- **name** – The *name* of a component must be globally unique because it is used as a PID in several places. The component name is used as a PID to retrieve component properties from the OSGi Configuration Admin service if present. See *Deployment* on page 302 for more information.
- **enabled** – Controls whether the component is *enabled* when the bundle is started. The default value is `true`. If `enabled` is set to `false`, the component is disabled until the method `enableComponent` is called on the `ComponentContext` object. This allows some initialization to be performed by some other component in the bundle before this component can become satisfied. See *Enabled* on page 294.
- **factory** – If set to a non-empty string, it indicates that this component is a *factory component*. SCR must register a Component Factory service for each factory component. See *Factory Component* on page 282.
- **immediate** – Controls whether component configurations must be immediately activated after becoming satisfied or whether activation should be delayed. The default value is `false` if the service element is specified and `true` otherwise. If this attribute is specified, its value must be `true` unless the service element is also specified.

112.4.4 Implementation Element

The implementation element is required and defines the name of the component implementation class. It has therefore only a single attribute:

- `class` – The Java fully qualified name of the implementation class.

The class is retrieved with the `loadClass` method of the component's bundle. The class must be public and have a public constructor without arguments (this is normally the default constructor) so component instances may be created by SCR with the `newInstance` method on `Class`.

If the component description specifies a service, the class must implement all interfaces that are provided by the service.

112.4.5 Properties and Property Elements

A component description can define a number of properties. There are two different elements for this:

- `property` – Defines a single property.
- `properties` – Reads a set of properties from a bundle entry.

The `property` and `properties` elements can occur multiple times and they can be interleaved. This interleaving is relevant because the properties are processed from top to bottom. Later properties override earlier properties that have the same name.

Properties can also be overridden by a Configuration Admin service's Configuration object before they are exposed to the component or used as service properties. This is described in *Component Properties* on page 301 and *Deployment* on page 302.

The `property` element has the following attributes:

- `name` – The name of the property.
- `value` – The value of the property. This value is parsed according to the property type. If the `value` attribute is specified, the body of the element is ignored. If the type of the property is not `String`, parsing of the value is done by the `valueOf(String)` method in the class identified by the type.
- `type` – The type of the property. Defines how to interpret the value. The type must be one of the following Java types:
 - `String` (default)
 - `Long`
 - `Double`
 - `Float`
 - `Integer`
 - `Byte`
 - `Char`
 - `Boolean`
 - `Short`
- `element body` – If the `value` attribute is not specified, the body of the property element must contain one or more values. The value of the property is then an array of the specified type. Except for `String` objects, the result will be translated to an array of primitive types. For example, if the type attribute specifies `Integer`, then the resulting array must be `int[]`.

Values must be placed one per line and blank lines are ignored. Parsing of the value is done by the parse methods in the class identified by the type, after trimming the line of any beginning and ending white space. String values are also trimmed of beginning and ending white space before being placed in the array.

For example, a component that needs an array of hosts can use the following property definition:

```
<property name="hosts">
    www.acme.com
    backup.acme.com
</property>
```

This property declaration results in the property hosts, with a value of `String[] { "www.acme.com", "backup.acme.com" }`.

The properties element references an entry in the bundle whose contents conform to a standard [54] *Java Properties File*.

The entry is read and processed to obtain the properties and their values. The properties element has the following attributes:

- entry – The entry path relative to the root of the bundle

For example, to include vendor identification properties that are stored in the OSGI-INF directory, the following definition could be used:

```
<properties entry="OSGI-INF/vendor.properties" />
```

112.4.6 Service Element

The service element is optional. It describes the service information to be used when a component configuration is to be registered as a service.

A service element has the following attribute:

- servicefactory – Controls whether the service uses the ServiceFactory concept of the OSGi Framework. The default value is false. If servicefactory is set to true, a different component configuration is created, activated and its component instance returned as the service object for each distinct bundle that requests the service. Each of these component configurations has the same component properties. Otherwise, the same component instance from the single component configuration is returned as the service object for all bundles that request the service.

The servicefactory attribute must not be true if the component is a factory component or an immediate component. This is because SCR is not free to create component configurations as necessary to support servicefactory. A component description is ill-formed if it specifies that the component is a factory component or an immediate component and servicefactory is set to true.

The service element must have one or more provide elements that define the service interfaces. The provide element has a single attribute:

- interface – The name of the interface that this service is registered under. This name must be the fully qualified name of a Java class. For example,

org.osgi.service.log.LogService. The specified Java class should be an interface rather than a class, however specifying a class is supported.

For example, a component implements an Event Handler service.

```
<service>
  <provide interface=
    "org.osgi.service.eventadmin.EventHandler"/>
</service>
```

112.4.7

Reference Element

A *reference* declares a dependency that a component has on a set of target services. A component configuration is not satisfied, unless all its references are satisfied. A reference specifies target services by specifying their interface and an optional target filter.

A reference element has the following attributes:

- **name** – The name of the reference. This name is local to the component and can be used to locate a bound service of this reference with one of the `locateService` methods of [ComponentContext](#).
- **interface** – Fully qualified name of the class that is used by the component to access the service. The service provided to the component must be type compatible with this class. That is, the component must be able to cast the service object to this class. A service must be registered under this name to be considered for the set of target services.
- **cardinality** – Specifies if the reference is optional and if the component implementation support a single bound service or multiple bound services. See *Reference Cardinality* on page 286.
- **policy** – The policy declares the assumption of the component about dynamicity. See *Reference Policy* on page 287.
- **target** – An optional OSGi Framework filter expression that further constrains the set of target services. The default is no filter, limiting the set of matched services to all service registered under the given reference interface. The value of this attribute is used to set a target property. See *Selecting Target Services* on page 288.
- **bind** – The name of a method in the component implementation class that is used to notify that a service is bound to the component configuration. For static references, this method is only called before the `activate` method. For dynamic references, this method can also be called while the component configuration is active. See *Accessing Services* on page 284.
- **unbind** – Same as `bind`, but is used to notify the component configuration that the service is unbound. For static references, the method is only called after the `deactivate` method. For dynamic references, this method can also be called while the component configuration is active. See *Accessing Services* on page 284.

112.5 Component Life Cycle

112.5.1 Enabled

A component must first be *enabled* before it can be used. A component cannot be enabled unless the component's bundle is started. All components in a bundle become disabled when the bundle is stopped. So the life cycle of a component is contained within the life cycle of its bundle.

Every component can be enabled or disabled. The initial enabled state of a component is specified in the component description via the `enabled` attribute of the component element. See *Component Element* on page 290. Component configurations can be created, satisfied and activated only when the component is enabled.

The enabled state of a component can be controlled with the Component Context `enableComponent(String)` and `disableComponent(String)` methods. The purpose of later enabling a component is to be able to decide programmatically when a component can become enabled. For example, an immediate component can perform some initialization work before other components in the bundle are enabled. The component descriptions of all other components in the bundle can be disabled by having `enabled` set to `false` in their component descriptions. After any necessary initialization work is complete, the immediate component can call `enableComponent` to enable the remaining components.

The `enableComponent` and `disableComponent` methods must return after changing the enabled state of the named component. Any actions that result from this, such as activating or deactivating a component configuration, must occur asynchronously to the method call. Therefore a component can disable itself.

All components in a bundle can be enabled by passing a null as the argument to `enableComponent`.

112.5.2 Satisfied

Component configurations can only be activated when the component configuration is *satisfied*. A component configuration becomes satisfied when the following conditions are all satisfied:

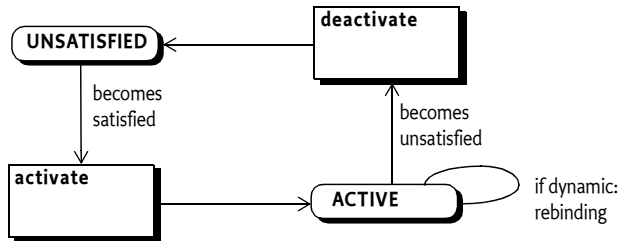
- The component is *enabled*.
- Using the component properties of the component configuration, all the component's references are satisfied. A reference is satisfied when the reference specifies optional cardinality or there is at least one target service for the reference.

Once any of the listed conditions are no longer true, the component configuration becomes *unsatisfied*. An activated component configuration that becomes unsatisfied, must be deactivated.

112.5.3 Immediate Component

A component is an immediate component when it must be activated as soon as its dependencies are satisfied. Once the component configuration becomes unsatisfied, the component configuration must be deactivated. If an immediate component configuration is satisfied and specifies a service, SCR must register the component configuration as a service in the service registry and then activate the component configuration. The state diagram is shown in Figure 45.

Figure 45 Immediate Component Configuration



112.5.4 Delayed Component

A key attribute of a delayed component is the delaying of class loading and object creation. Therefore, the activation of a delayed component configuration does not occur until there is an actual request for a service object. A component is a delayed component when it specifies a service but it is not a factory component and does not have the immediate attribute of the component element set to true.

SCR must register a service after the component configuration becomes satisfied. The registration of this service must look to observers of the service registry as if the component's bundle actually registered this service. This strategy makes it possible to register services without creating a class loader for the bundle and loading classes, thereby allowing reduction in initialization time and a delay in memory footprint.

When SCR registers the service on behalf of a component configuration, it must avoid causing a class load to occur from the component's bundle. SCR can ensure this by registering a ServiceFactory object with the Framework for that service. By registering a ServiceFactory object, the actual service object is not needed until the ServiceFactory is called to provide the service object.

The service properties for this registration consist of the component properties as defined in *Component Properties* on page 301.

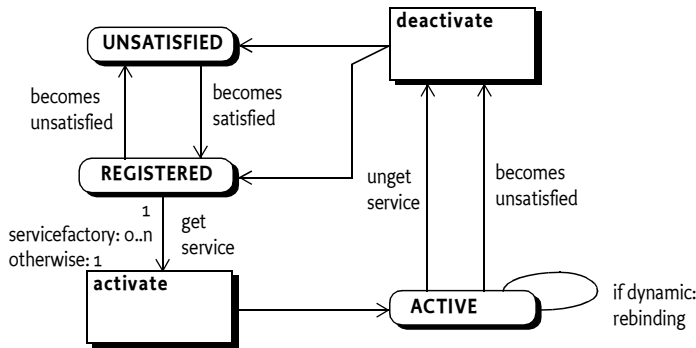
The activation of a component configuration must be delayed until its service is requested. When the service is requested, if the service has the servicefactory attribute set to true, SCR must create and activate a unique component configuration for each bundle requesting the service. Other-

wise, SCR must activate a single component configuration which is used by all bundles requesting the service. A component instance can determine the bundle it was activated for by calling the `getUsingBundle()` method on the Component Context.

The activation of delayed components is depicted in a state diagram in Figure 46. Notice that multiple component configurations can be created from the REGISTERED state if a delayed component specifies `servicefactory` set to `true`.

If the service registered by a component configuration becomes unused because there are no more bundles using it, then SCR should deactivate that component configuration. This allows SCR implementations to eagerly reclaim activated component configurations.

Figure 46 Delayed Component Configuration



112.5.5 Factory Component

SCR must register a Component Factory service as soon as the *component factory* becomes satisfied. The component factory is satisfied when the following conditions are all satisfied:

- The component is enabled.
- Using the component properties specified by the component description, all the component's references are satisfied. A reference is satisfied when the reference specifies optional cardinality or there is at least one target service for the reference

The component factory, however, does not use any of the target services and does not bind to them.

Once any of the listed conditions are no longer true, the component factory becomes unsatisfied and the Component Factory service must be unregistered. Any component configurations activated via the component factory are unaffected by the unregistration of the Component Factory service, but may themselves become unsatisfied for the same reason.

The Component Factory service must be registered under the name `org.osgi.service.component.ComponentFactory` with the following service properties:

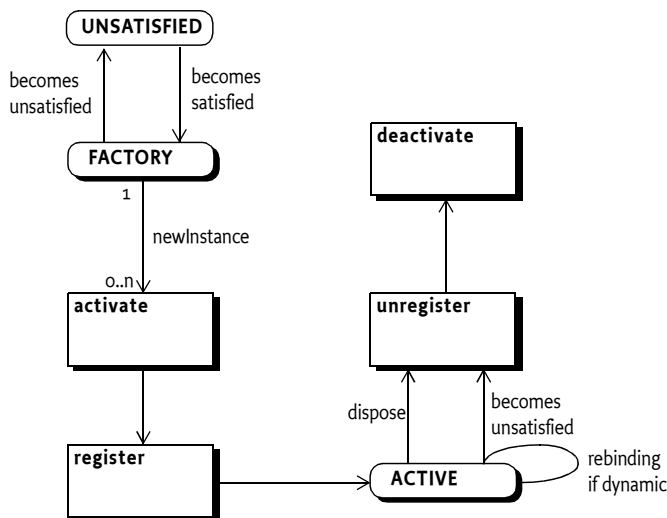
- `component.name` – The name of the component.

- `component.factory` – The value of the factory attribute.

New component configurations are created and activated when the `newInstance` method of the Component Factory service is called. If the component description specifies a service, the component configuration is registered under the provided interfaces and the component properties as defined in *Component Properties* on page 301. The service registration must take place before the component configuration is activated. Service unregistration must take place before the component configuration is deactivated.

Figure 47

Factory Component



A Component Factory service has a single method: `newInstance(Dictionary)`. This method must create, satisfy and activate a new component configuration and register its component instance as a service if the component description specifies a service. It must then return a `ComponentInstance` object. This `ComponentInstance` object can be used to get the component instance with the `getInstance()` method.

SCR must attempt to satisfy the component configuration created by `newInstance` before activating it. If SCR is unable to satisfy the component configuration given the component properties and the Dictionary argument to `newInstance`, the `newInstance` method must throw a `ComponentException`.

The client of the Component Factory service can also deactivate a component configuration with the `dispose()` method on the `ComponentInstance` object. If the component configuration is already deactivated, or is being deactivated, then this method is ignored. Also, if the component configuration becomes unsatisfied for any reason, it must be deactivated by SCR.

112.5.6

Activation

Activating a component configuration consists of the following steps:

- 1 Load the component implementation class.

- 2 Create the component instance and component context.
- 3 Bind the target services. See *Binding Services* on page 298.
- 4 Call the activate method, if present. See *Activate Method* on page 298.

Component instances must never be reused. Each time a component configuration is activated, SCR must create a new component instance to use with the activated component configuration. Once the component configuration is deactivated or fails to activate, SCR must discard all references to the component instance associated with the activation.

112.5.7 Binding Services

When a component configuration's reference is satisfied, there is a set of zero or more target services for that reference. When the component configuration is activated, a subset of the target services for each reference are bound to the component configuration. The subset is chosen by the cardinality of the reference. See *Reference Cardinality* on page 286.

When binding services, the references are processed in the order in which they are specified in the component description. That is, target services from the first specified reference are bound before services from the next specified reference.

For each reference using the event strategy, the bind method must be called for each bound service of that reference. This may result in activating a component configuration of the bound service which could result in an exception. If the loss of the bound service due to the exception causes the reference's cardinality constraint to be violated, then activation of this component configuration will fail. Otherwise the bound service which failed to activate will be considered unbound. If a bind method throws an exception, SCR must log an error message containing the exception with the Log Service, if present, but the activation of the component configuration does not fail.

112.5.8 Activate Method

A component implementation class can have a method called activate that takes a `ComponentContext` object as argument. The prototype of this method is:

```
protected void activate(ComponentContext context);
```

If the component implementation class defines such an activate method, SCR must call this method to complete the activation of the component configuration. If the activate method throws an exception, SCR must log an error message containing the exception with the Log Service, if present, and the component configuration is not activated.

The activate method will be called by SCR using reflection and must be a protected or public method. This method should not be a public method so that it does not appear as a public method on the component instance if it is registered as a service. SCR will look through the component implementation class hierarchy for the first declaration of the method. If the method is declared protected or public, SCR will call the method.

112.5.9 Component Context

The Component Context is made available to a component instance via the `activate` and `deactivate` methods. It provides the interface to the execution context of the component, much like the Bundle Context provides a bundle the interface to the Framework. A Component Context should therefore be regarded as a capability and not shared with other components or bundles.

Each distinct component instance receives a unique Component Context. Component Contexts are not reused and must be discarded when the component configuration is deactivated.

112.5.10 Bound Service Replacement

If an active component configuration has a dynamic reference with unary cardinality and the bound service is modified or unregistered and ceases to be a target service, SCR must attempt to replace the bound service with a new target service. SCR must first bind a replacement target service and then unbind the outgoing service. If the dynamic reference has a mandatory cardinality and no replacement target service is available, the component configuration must be deactivated because the cardinality constraints will be violated.

If a component configuration has a static reference and a bound service is modified or unregistered and ceases to be a target service, SCR must deactivate the component configuration. Afterwards, SCR must attempt to activate the component configuration again if another target service can be used as a replacement for the outgoing service.

112.5.11 Deactivation

Deactivating a component configuration consists of the following steps:

- 1 Call the `deactivate` method, if present. See *Deactivate Method* on page 299.
- 2 Unbind any bound services. See *Unbinding* on page 300.
- 3 Release all references to the component instance and component context.

Once the component configuration is deactivated, SCR must discard all references to the component instance associated with the activation.

112.5.12 Deactivate Method

A component implementation class can have a method called `deactivate` that takes a `ComponentContext` object as argument. The prototype of this method is:

```
protected void deactivate(ComponentContext context);
```

If the component implementation class defines such an `deactivate` method, SCR must call this method to commence the deactivation of the component configuration. If the `deactivate` method throws an exception, SCR must log an error message containing the exception with the Log Service, if present, and the deactivation of the component configuration will continue.

The deactivate method will be called by SCR using reflection and must be a protected or public method. This method should not be a public method so that it does not appear as a public method on the component instance if it is registered as a service. SCR will look through the component implementation class hierarchy for the first declaration of the method. If the method is declared protected or public, SCR will call the method.

112.5.13 Unbinding

When a component configuration is deactivated, the bound services are unbound from the component configuration.

When unbinding services, the references are processed in the reverse order in which they are specified in the component description. That is, target services from the last specified reference are unbound before services from the previous specified reference.

For each reference using the event strategy, the unbind method must be called for each bound service of that reference. If an unbind method throws an exception, SCR must log an error message containing the exception with the Log Service, if present, and the deactivation of the component configuration will continue.

112.5.14 Life Cycle Example

A component could declare a dependency on the Http Service to register some resources.

```
<?xml version="1.0" encoding="UTF-8"?>
<component name="example.binding">
  <implementation class="example.Binding"/>
  <reference name="LOG"
    interface="org.osgi.service.log.LogService"
    cardinality="1..1"
    policy="static"
  />
  <reference name="HTTP"
    interface="org.osgi.service.http.HttpService"
    cardinality="0..1"
    policy="dynamic"
    bind="setHttp"
    unbind="unsetHttp"
  />
</component>
```

The component implementation code looks like:

```
public class Binding {
    LogService log;
    HttpService http;

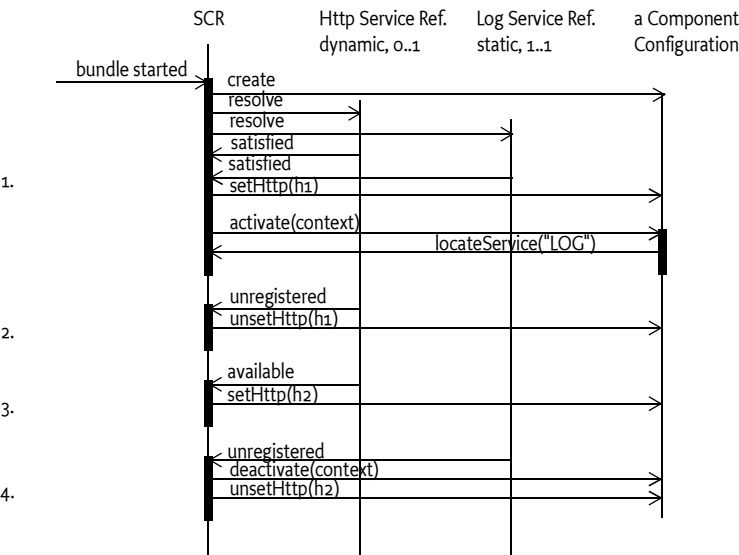
    protected void setHttp(HttpService h) {
        this.http = h;
        // register servlet
    }
    protected void unsetHttp(HttpService h){
```

```
        this.h = null;
        // unregister servlet
    }
    protected void activate(ComponentContext context ) {
        log = (LogService) context.locateService("LOG");
    }
    protected void deactivate(ComponentContext context ){...}
}
```

This example is depicted in a sequence diagram in Figure 48. with the following scenario:

- 1 A bundle with the example.Binding component is started. At that time there is a Log Service l1 and a Http Service h1 registered.
- 2 The Http Service h1 is unregistered
- 3 A new Http Service h2 is registered
- 4 The Log Service h1 is unregistered.

Figure 48 Sequence Diagram for binding



112.6 Component Properties

Each component configuration is associated with a set of component properties. The component properties are specified in the following places (in order of precedence):

- 1 Properties specified in the argument of ComponentFactory.newInstance method. This is only applicable for factory components.
- 2 Properties retrieved from the OSGi Configuration Admin service with a Configuration object that has a PID equal to the name of the component.

- 3 Properties specified in the component description. Later properties override earlier properties that have the same name. Properties can be specified in the component description in the following ways:
 - Target properties – The key of a target properties is the name of the reference appended with `.target`. The value of these properties is the value of the target attribute of the reference. For example, a reference with the name `http` whose target attribute has the value `"(http.port=80)"` results in the component property having the name `http.target` and value `"(http.port=80)"`. The target property is not set if the target attribute of the reference is not specified. See *Selecting Target Services* on page 288.
 - property and properties elements – See *Properties and Property Elements* on page 291.

The precedence behavior allows certain default values to be specified in the component description while allowing properties to be replaced and extended by:

- A configuration in Configuration Admin
- The argument to `ComponentFactory.newInstance` method

SCR always adds the following component properties, which can not be overridden:

- `component.name` – The component name.
- `component.id` – A unique value (Long) that is larger than all previously assigned values. These values are not persistent across restarts of SCR.

112.7 Deployment

A component description contains default information to select target services for each reference. However, when a component is deployed, it is often necessary to influence the target service selection in a way that suits the need of the deployer. Therefore, SCR uses Configuration objects from Configuration Admin to replace and extend the component properties for a component configuration. That is, through Configuration Admin a deployer can configure component properties.

The name of the component is used as the key for obtaining additional component properties from Configuration Admin. The following situations can arise:

- *No Configuration* – If there is no Configuration with a PID or factory PID equal to the component name, then component configurations will not obtain component properties from Configuration Admin. Only component properties specified in the component description or via the `ComponentFactory.newInstance` method will be used.
- *Single Configuration* – If there exists a Configuration with a PID equal to the component name, then component configurations will obtain additional component properties from Configuration Admin. This is the *ManagedService* situation.
- *Factory Configuration* – If a factory PID exists, with zero or more Configurations, that is equal to the component name, then for each Configuration, a component configuration must be created that will obtain

additional component properties from Configuration Admin. This is the `ManagedServiceFactory` situation.

A factory configuration must not be used if the component is a factory component. This is because SCR is not free to create component configurations as necessary to support multiple Configurations. When SCR detects this condition, it must log an error message with the Log Service, if present, and ignore the component description.

SCR must obtain the Configuration objects from the Configuration Admin service using the Bundle Context of the bundle containing the component.

For example, there is a component named `com.acme.client` with a reference named `HTTP` that requires an `Http Service` which must be bound to a component `com.acme.httpserver` which provides an `Http Service`. A deployer can establish the following configuration:

```
[PID=com.acme.client, factoryPID=null]
HTTP.target = (component.name=com.acme.httpserver)
```

SCR must track changes in the Configuration objects used in the component properties of a component configuration. If a Configuration object that is related to a component configuration changes, then SCR must deactivate that component configuration and, if the Configuration object was not deleted, SCR must attempt to reactive the component configuration with the updated component properties.

112.8 Service Component Runtime

112.8.1 Relationship to OSGi Framework

SCR must have access to the Bundle Context of any bundle that contains a component. There is currently no defined way to obtain the Bundle Context of a bundle. A Bundle Context is only provided to a bundle via its Bundle Activator methods. This implies that SCR requires a private interface to the Framework implementation to obtain Bundle Contexts. SCR needs access to the Bundle Context for the following reasons:

- To be able to register and get services on behalf of a bundle with components.
- To interact with the Configuration Admin on behalf of a bundle with components.
- To provide a component its Bundle Context when the Component Context `getBundleContext` method is called.

Since the Bundle Context is considered a private object to the bundle and would provide the capability for the receiver of the object to act as the bundle, there is no specified way for the OSGi Framework to provide a BundleContext object to other bundles.

112.8.2 Starting and Stopping SCR

When SCR is implemented as a bundle, any component configurations activated by SCR must be deactivated when the SCR bundle is stopped. When the SCR bundle is started, it must process any components that are declared in ACTIVE bundles.

112.9 Security

112.9.1 Service Permissions

Declarative services are built upon the existing OSGi service infrastructure. This means that Service Permission applies regarding the ability to publish, find or bind services.

If a component specifies a service, then component configurations for the component cannot be satisfied unless the component's bundle has ServicePermission[<provides>, REGISTER] for each provided interface specified for the service.

If a component's reference does not specify optional cardinality, the reference cannot be satisfied unless the component's bundle has ServicePermission[<interface>, GET] for the specified interface in the reference. If the reference specifies optional cardinality but the component's bundle does not have ServicePermission[<interface>, GET] for the specified interface in the reference, no service must be bound for this reference.

If a component is a factory component, then the above Service Permission checks still apply. But the component's bundle is not required to have ServicePermission[ComponentFactory, REGISTER] as the Component Factory service is registered by SCR.

112.9.2 Using hasPermission

SCR does all publishing, finding and binding of services on behalf of the component using the Bundle Context of the component's bundle. This means that normal stack-based permission checks will check SCR and not the component's bundle. Since SCR is registering and getting services on behalf of a component's bundle, SCR must call the Bundle.hasPermission method to validate that a component's bundle has the necessary permission to register or get a service.

112.10 Component Description Schema

This XML Schema defines the component description grammar.

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
  targetNamespace="http://www.osgi.org/xmlns/scr/v1.0.0"
  xmlns:scr="http://www.osgi.org/xmlns/scr/v1.0.0">

  <element name="component" type="scr:Tcomponent"/>

  <complexType name="Tcomponent">
    <sequence>
      <element name="implementation" type="scr:Timplementation" minOccurs="1" maxOccurs="1"/>
      <choice minOccurs="0" maxOccurs="unbounded">
        <element name="property" type="scr:Tproperty"/>
        <element name="properties" type="scr:Tproperties"/>
      </choice>
      <element name="service" type="scr:Tservice" minOccurs="0" maxOccurs="1"/>
      <element name="reference" type="scr:Treference" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="enabled" type="boolean" default="true" use="optional"/>
    <attribute name="name" type="token" use="required"/>
    <attribute name="factory" type="string" use="optional"/>
    <attribute name="immediate" type="boolean" use="optional"/>
  </complexType>
</schema>
```

```

</complexType>

<complexType name="Timplementation">
  <attribute name="class" type="token" use="required"/>
</complexType>

<complexType name="Tproperty">
  <simpleContent>
    <extension base="string">
      <attribute name="name" type="string" use="required"/>
      <attribute name="value" type="string" use="optional"/>
      <attribute name="type" type="scr:TjavaTypes" default="String" use="optional"/>
    </extension>
  </simpleContent>
</complexType>

<complexType name="Tproperties">
  <attribute name="entry" type="string" use="required"/>
</complexType>

<complexType name="Tservice">
  <sequence>
    <element name="provide" type="scr:Tprovide" minOccurs="1" maxOccurs="unbounded"/>
  </sequence>
  <attribute name="servicefactory" type="boolean" default="false" use="optional"/>
</complexType>

<complexType name="Tprovide">
  <attribute name="interface" type="token" use="required"/>
</complexType>

<complexType name="Treference">
  <attribute name="name" type="NMTOKEN" use="required"/>
  <attribute name="interface" type="token" use="required"/>
  <attribute name="cardinality" type="scr:Tcardinality" default="1..1" use="optional"/>
  <attribute name="policy" type="scr:Tpolicy" default="static" use="optional"/>
  <attribute name="target" type="string" use="optional"/>
  <attribute name="bind" type="token" use="optional"/>
  <attribute name="unbind" type="token" use="optional"/>
</complexType>

<simpleType name="TjavaTypes">
  <restriction base="string">
    <enumeration value="String"/>
    <enumeration value="Long"/>
    <enumeration value="Double"/>
    <enumeration value="Float"/>
    <enumeration value="Integer"/>
    <enumeration value="Byte"/>
    <enumeration value="Char"/>
    <enumeration value="Boolean"/>
    <enumeration value="Short"/>
  </restriction>
</simpleType>

<simpleType name="Tcardinality">
  <restriction base="string">
    <enumeration value="0..1"/>
    <enumeration value="0..n"/>
    <enumeration value="1..1"/>
    <enumeration value="1..n"/>
  </restriction>
</simpleType>

<simpleType name="Tpolicy">
  <restriction base="string">
    <enumeration value="static"/>
    <enumeration value="dynamic"/>
  </restriction>
</simpleType>
</schema>

```

112.11 org.osgi.service.component

The OSGi Service Component Package. Specification Version 1.0.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.service.component; version=1.0

112.11.1 Summary

- **ComponentConstants** - Defines standard names for Service Component constants. [p.306]
- **ComponentContext** - A Component Context object is used by a component instance to interact with its execution context including locating services by reference name. [p.307]
- **ComponentException** - Unchecked exception which may be thrown by the Service Component Runtime. [p.309]
- **ComponentFactory** - When a component is declared with the factory attribute on its component element, the Service Component Runtime will register a Component Factory service to allow new component configurations to be created and activated rather than automatically creating and activating component configuration as necessary. [p.310]
- **ComponentInstance** - A ComponentInstance encapsulates a component instance of an activated component configuration. [p.310]

112.11.2 public interface ComponentConstants

Defines standard names for Service Component constants.

112.11.2.1 public static final String COMPONENT_FACTORY = "component.factory"

A service registration property for a Component Factory that contains the value of the factory attribute. The type of this property must be String.

112.11.2.2 public static final String COMPONENT_ID = "component.id"

A component property that contains the generated id for a component configuration. The type of this property must be Long.

The value of this property is assigned by the Service Component Runtime when a component configuration is created. The Service Component Runtime assigns a unique value that is larger than all previously assigned values since the Service Component Runtime was started. These values are NOT persistent across restarts of the Service Component Runtime.

112.11.2.3 public static final String COMPONENT_NAME = "component.name"

A component property for a component configuration that contains the name of the component as specified in the name attribute of the component element. The type of this property must be String.

112.11.2.4 public static final String REFERENCE_TARGET_SUFFIX = ".target"

The suffix for reference target properties. These properties contain the filter to select the target services for a reference. The type of this property must be String.

112.11.2.5 public static final String SERVICE_COMPONENT = "Service-Component"

Manifest header (named "Service-Component") specifying the XML documents within a bundle that contain the bundle's Service Component descriptions.

The attribute value may be retrieved from the Dictionary object returned by the `Bundle.getHeaders` method.

112.11.3 public interface ComponentContext

A Component Context object is used by a component instance to interact with its execution context including locating services by reference name. Each component instance has a unique Component Context.

A component's implementation class may optionally implement an activate method:

```
protected void activate(ComponentContext context);
```

If a component implements this method, this method will be called when a component configuration is activated to provide the component instance's Component Context object.

A component's implementation class may optionally implement a deactivate method:

```
protected void deactivate(ComponentContext context);
```

If a component implements this method, this method will be called when the component configuration is deactivated.

The activate and deactivate methods will be called using reflection and must be protected or public accessible. These methods should not be public methods so that they do not appear as public methods on the component instance when used as a service object. These methods will be located by looking through the component's implementation class hierarchy for the first declaration of the method. If the method is found, if it is declared protected or public, the method will be called. Otherwise, the method will not be called.

112.11.3.1 public void disableComponent(String name)

name The name of a component.

- ❑ Disables the specified component name. The specified component name must be in the same bundle as this component.

112.11.3.2 public void enableComponent(String name)

name The name of a component or null to indicate all components in the bundle.

- ❑ Enables the specified component name. The specified component name must be in the same bundle as this component.

112.11.3.3 public BundleContext getBundleContext()

- ❑ Returns the BundleContext of the bundle which contains this component.

Returns The BundleContext of the bundle containing this component.

112.11.3.4 public ComponentInstance getComponentInstance()

- Returns the Component Instance object for the component instance associated with this Component Context.

Returns The Component Instance object for the component instance.

112.11.3.5 public Dictionary getProperties()

- Returns the component properties for this Component Context.

Returns The properties for this Component Context. The Dictionary is read only and cannot be modified.

112.11.3.6 public ServiceReference getServiceReference()

- If the component instance is registered as a service using the service element, then this method returns the service reference of the service provided by this component instance.

This method will return null if the component instance is not registered as a service.

Returns The ServiceReference object for the component instance or null if the component instance is not registered as a service.

112.11.3.7 public Bundle getUsingBundle()

- If the component instance is registered as a service using the servicefactory="true" attribute, then this method returns the bundle using the service provided by the component instance.

This method will return null if:

- The component instance is not a service, then no bundle can be using it as a service.
- The component instance is a service but did not specify the servicefactory="true" attribute, then all bundles using the service provided by the component instance will share the same component instance.
- The service provided by the component instance is not currently being used by any bundle.

Returns The bundle using the component instance as a service or null.

112.11.3.8 public Object locateService(String name)

name The name of a reference as specified in a reference element in this component's description.

- Returns the service object for the specified reference name.

If the cardinality of the reference is 0..n or 1..n and multiple services are bound to the reference, the service with the highest ranking (as specified in its Constants.SERVICE_RANKING property) is returned. If there is a tie in ranking, the service with the lowest service ID (as specified in its Constants.SERVICE_ID property); that is, the service that was registered first is returned.

Returns A service object for the referenced service or null if the reference cardinality is 0..1 or 0..n and no bound service is available.

Throws ComponentException – If the Service Component Runtime catches an exception while activating the bound service.

112.11.3.9 public Object locateService(String name, ServiceReference reference)

name The name of a reference as specified in a reference element in this component's description.

reference The ServiceReference to a bound service. This must be a ServiceReference provided to the component via the bind or unbind method for the specified reference name.

- Returns the service object for the specified reference name and ServiceReference.

Returns A service object for the referenced service or null if the specified ServiceReference is not a bound service for the specified reference name.

Throws ComponentException – If the Service Component Runtime catches an exception while activating the bound service.

112.11.3.10 public Object[] locateServices(String name)

name The name of a reference as specified in a reference element in this component's description.

- Returns the service objects for the specified reference name.

Returns An array of service objects for the referenced service or null if the reference cardinality is 0..1 or 0..n and no bound service is available.

Throws ComponentException – If the Service Component Runtime catches an exception while activating a bound service.

**112.11.4 public class ComponentException
 extends RuntimeException**

Unchecked exception which may be thrown by the Service Component Runtime.

112.11.4.1 public ComponentException(String message, Throwable cause)

message The message for the exception.

cause The cause of the exception. May be null.

- Construct a new ComponentException with the specified message and cause.

112.11.4.2 public ComponentException(String message)

message The message for the exception.

- Construct a new ComponentException with the specified message.

112.11.4.3 public ComponentException(Throwable cause)

cause The cause of the exception. May be null.

- Construct a new ComponentException with the specified cause.

112.11.4.4 public Throwable getCause()

- Returns the cause of this exception or null if no cause was specified when this exception was created.

Returns The cause of this exception or null if no cause was specified.

112.11.4.5 public Throwable initCause(Throwable cause)

cause Cause of the exception.

- The cause of this exception can only be set when constructed.

Returns This object.

Throws `IllegalStateException` – This method will always throw an `IllegalStateException` since the cause of this exception can only be set when constructed.

112.11.5 public interface ComponentFactory

When a component is declared with the factory attribute on its component element, the Service Component Runtime will register a Component Factory service to allow new component configurations to be created and activated rather than automatically creating and activating component configuration as necessary.

112.11.5.1 public ComponentInstance newInstance(Dictionary properties)

properties Additional properties for the component configuration.

- Create and activate a new component configuration. Additional properties may be provided for the component configuration.

Returns A `ComponentInstance` object encapsulating the component instance of the component configuration. The component configuration has been activated and, if the component specifies a service element, the component instance has been registered as a service.

Throws `ComponentException` – If the Service Component Runtime is unable to activate the component configuration.

112.11.6 public interface ComponentInstance

A `ComponentInstance` encapsulates a component instance of an activated component configuration. `ComponentInstances` are created whenever a component configuration is activated.

`ComponentInstances` are never reused. A new `ComponentInstance` object will be created when the component configuration is activated again.

112.11.6.1 public void dispose()

- Dispose of the component configuration for this component instance. The component configuration will be deactivated. If the component configuration has already been deactivated, this method does nothing.

112.11.6.2 public Object getInstance()

- Returns the component instance of the activated component configuration.

Returns The component instance or null if the component configuration has been deactivated.

112.12 References

- [52] *Automating Service Dependency Management in a Service-Oriented Component Model*
Humberto Cervantes, Richard S. Hall, Proceedings of the Sixth Component-Based Software Engineering Workshop, May 2003, pp. 91-96.
http://www.osgi.org/news_events/documents/AutoServDependencyMgmt_byHall_Cervantes.pdf
- [53] *Service Binder*
Humberto Cervantes, Richard S. Hall, <http://gravity.sourceforge.net/servicebinder>
- [54] *Java Properties File*
[http://java.sun.com/j2se/1.4.2/docs/api/java/util/Properties.html#load\(java.io.InputStream\)](http://java.sun.com/j2se/1.4.2/docs/api/java/util/Properties.html#load(java.io.InputStream))

113 Event Admin Service Specification

Version 1.0

113.1 Introduction

Nearly all the bundles in an OSGi framework must deal with events, either as an event publisher or as an event handler. So far, the preferred mechanism to disperse those events have been the service interface mechanism.

Dispatching events for a design related to X, usually involves a service of type `XListener`. However, this model does not scale well for fine grained events that must be dispatched to many different handlers. Additionally, the dynamic nature of the OSGi environment introduces several complexities because both event publishers and event handlers can appear and disappear at any time.

The Event Admin service provides an inter-bundle communication mechanism. It is based on a event *publish* and *subscribe* model, popular in many message based systems.

This specification defines the details for the participants in this event model.

113.1.1 Essentials

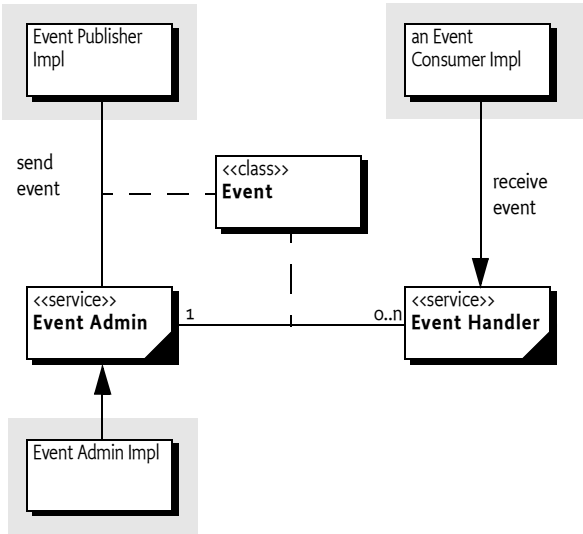
- *Simplifications* – The model must significantly simplify the process of programming an event source and an event handler.
- *Dependencies* – Handle the myriad of dependencies between event sources and event handlers for proper cleanup.
- *Synchronicity* – It must be possible to deliver events asynchronously or synchronously with the caller.
- *Event Window* – Only event handlers that are active when an event is published must receive this event, handlers that register later must not see the event.
- *Performance* – The event mechanism must impose minimal overhead in delivering events.
- *Selectivity* – Event listeners must only receive notifications for the event types for which they are interested
- *Reliability* – The Event Admin must ensure that events continue to be delivered regardless the quality of the event handlers.
- *Security* – Publishing and receiving events are sensitive operations that must be protected per event type.
- *Extensibility* – It must be possible to define new event types with their own data types.
- *Native Code* – Events must be able to be passed to native code or come from native code.

- *OSGi Events* – The OSGi Framework, as well as a number of OSGi services, already have number of its own events defined. For uniformity of processing, these have to be mapped into generic event types.

113.1.2 Entities

- *Event* – An Event object has a topic and a Dictionary object that contains the event properties. It is an immutable object.
- *Event Admin* – The service that provides the publish and subscribe model to Event Handlers and Event Publishers.
- *Event Handler* – A service that receives and handles Event objects.
- *Event Publisher* – A bundle that sends event through the Event Admin service.
- *Event Subscriber* – Another name for an Event Handler.
- *Topic* – The name of an Event type.
- *Event Properties* – The set of properties that is associated with an Event.

Figure 49 The Event Admin service org.osgi.service.event package



113.1.3 Synopsis

The Event Admin service provides a place for bundles to publish events, regardless of their destination. It is also used by Event Handlers to subscribe to specific types of events.

Events are published under a topic, together with a number of event properties. Event Handlers can specify a filter to control the Events they receive on a very fine grained basis.

113.1.4 What To Read

- *Architects* – The *Event Admin Architecture* on page 315 provides an overview of the Event Admin service.

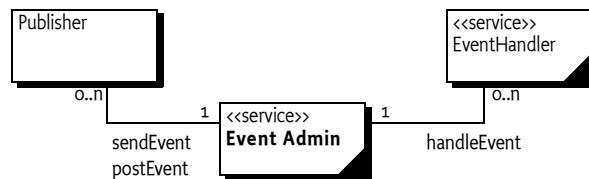
- *Event Publishers* – The *Event Publisher* on page 317 provides an introduction of how to write an Event Publisher. The *Event Admin Architecture* on page 315 provides a good overview of the design.
- *Event Subscribers/Handlers* – The *Event Handler* on page 316 provides the rules on how to subscribe and handle events.

113.2 Event Admin Architecture

The Event Admin is based on the *Publish-Subscribe* pattern. This pattern decouples sources from their handlers by interposing an *event channel* between them. The publisher posts events to the channel, which identifies which handlers need to be notified and then takes care of the notification process. This model is depicted in Figure 50.

Figure 50

Channel Pattern



In this model, the event source and event handler are completely decoupled because neither has any direct knowledge of the other. The complicated logic of monitoring changes in the event publishers and event handlers is completely contained within the event channel. This is highly advantageous in an OSGi environment because it simplifies the process of both sending and receiving events.

113.3 The Event

Events have the following attributes:

- *Topic* – A topic that defines what happened. For example, when a bundle is started an event is published that has a topic of `org/osgi/framework/BundleEvent/STARTED`.
- *Properties* – Zero or more properties that contain additional information about the event. For example, the previous example event has a property of `bundle.id` which is set to a Long object, among other properties.

113.3.1 Topics

The topic of an event defines the *type* of the event. It is fairly granular in order to give handlers the opportunity to register for just the events they are interested in. When a topic is designed, its name should not include any other information, such as the publisher of the event or the data associated with the event, those parts are intended to be stored in the event properties.

The topic is intended to serve as a first-level filter for determining which handlers should receive the event. Event Admin service implementations use the structure of the topic to optimize the dispatching of the events to the handlers.

Topics are arranged in a hierarchical name space. Each level is defined by a token and levels are separated by slashes. More precisely, the topic must conform to the following grammar:

```
topic ::= token ( '/' token ) *    // See 1.4.2 Core book
```

Topics should be designed to become more specific when going from left to right. Handlers can provide a prefix that matches a topic, using the preferred order allows a handler to minimize the number of prefixes it needs to register.

Topics are case sensitive. As a convention, topics should follow the reverse domain name scheme used by Java packages to guarantee uniqueness. The separator must be slashes ('/' \u002F) instead of the dot ('.' \u002E).

This specification uses the convention fully/qualified/package/ClassName/ACTION. If necessary, a pseudo-class-name is used.

113.3.2

Properties

Information about the actual event is provided as properties. The property name is a case-sensitive string and the value can be any object. Although any Java object can be used as a property value, only String objects and the eight primitive types (plus their wrappers) should be used. Other types cannot be passed to handlers that reside external from the Java VM.

Another reason that arbitrary classes should not be used is the mutability of objects. If the values are not immutable, then any handler that receives the event could change the value. Any handlers that received the event subsequently would see the altered value and not the value as it was when the event was sent.

The topic of the event is available as a property with the key [EVENT_TOPIC](#). This allows filters to include the topic as a condition if necessary.

113.4 Event Handler

Event handlers must be registered as services with the OSGi framework under the object class `org.osgi.service.event.EventHandler`.

Event handlers should be registered with a property (constant from the `EventConstants` class) [EVENT_TOPIC](#). The value being a `String[]` object that describes which *topics* the handler is interested in. A wildcard ('*' \u002A) may be used as the last token of a topic name, for example `com/action/*`. This matches any topic that shares the same first tokens. For example, `com/action/*` matches `com/action/listen`.

Event Handlers which do not have a value for the topic property must not receive events.

The value of each entry in the [EVENT_TOPIC](#) service registration property must conform to the following grammar:

```
topic-scope ::= '*' | ( topic [ '/' '*' ] )
```

Event handlers can also be registered with a service property named `EVENT_FILTER`. The value of this property must be a string containing a Framework filter specification. Any of the event's properties can be used in the filter expression.

```
event-filter ::= filter           // 3.2.6 Core book
```

Each Event Handler is notified for any event which belongs to the topics the handler has expressed an interest in. If the handler has defined a `EVENT_FILTER` service property then the event properties must also match the filter expression. If the filter is an error, then the Event Admin service should log a warning and further ignore the Event Handler.

For example, a bundle wants to see all Log Service events with a level of `WARNING` or `ERROR`, but it must ignore the `INFO` and `DEBUG` events. Additionally, the only events of interest are when the bundle symbolic name starts with `com.acme`.

```
public AcmeWatchDog implements Activator, EventHandler {
    final static String [] topics = new String[] {
        "org.osgi/service/log/LogEntry/LOG_WARNING",
        "org.osgi/service/log/LogEntry/LOG_ERROR" };

    public void start(BundleContext context) {
        Dictionary d = new Hashtable();
        d.put(EventConstants.EVENT_TOPICS, topics );
        d.put(EventConstants.EVENT_FILTER,
            "(bundle.symbolicName=com.acme.*)" );
        context.registerService( EventHandler.class.getName(),
            this, d );
    }
    public void stop( BundleContext context) {}

    public void handleEvent(Event event ) {
        //...
    }
}
```

If there are multiple Event Admin services registered with the Framework then all Event Admin services must send their published events to all registered Event Handlers.

113.5 Event Publisher

To fire an event, the event source must retrieve the Event Admin service from the OSGi service registry. Then it creates the event object and calls one of the Event Admin service's methods to fire the event either synchronously or asynchronously.

The following example is a class that publishes a time event every 60 seconds.

```
public class TimerEvent extends Thread
    implements BundleActivator {
    Hashtable      time = new Hashtable();
```

```

ServiceTracker tracker;

public TimerEvent() { super("TimerEvent"); }

public void start(BundleContext context ) {
    tracker = new ServiceTracker(context,
        EventAdmin.class.getName(), null );
    start();
}

public void stop( BundleContext context ) {
    interrupt();
}

public void run() {
    while ( ! Thread.interrupted() ) try {
        Calendar c = Calendar.getInstance();
        set(c, Calendar.MINUTES, "minutes");
        set(c, Calendar.HOURS, "hours");
        set(c, Calendar.DAY_OF_MONTH, "day");
        set(c, Calendar.MONTH, "month");
        set(c, Calendar.YEAR, "year");

        EventAdmin ea = (EventAdmin) tracker.getService();
        if ( ea != null )
            ea.sendEvent(new Event("com/acme/timer", time ));

        Thread.sleep(60000-c.get(Calendar.SECOND)*1000);
    } catch( InterruptedException e ) {
        // ignore, treated by while loop
    }
}

void set( Calendar c, int field, String key ) {
    time.put( key, new Integer(c.get(field)) );
}
}

```

113.6 Specific Events

113.6.1 General Conventions

Some handlers are more interested in the contents of an event rather than what actually happened. For example, a handler wants to be notified whenever an Exception is thrown anywhere in the system. Both Framework Events and Log Entry events may contain an exception that would be of interest to this hypothetical handler. If both Framework Events and Log Entries use the same property names then the handler can access the Exception in exactly the same way. If some future event type follows the same

conventions then the handler can receive and process the new event type even though it had no knowledge of it when it was compiled.

The following properties are suggested as conventions. When new event types are defined they should use these names with the corresponding types and values where appropriate. These values should be set only if they are not null

A list of these property names can be found in Table 23..

Table 23

General property names for events

Name	Type	Notes
BUNDLE_SIGNER	String	A signer DN
BUNDLE_SYMBOLICNAME	String	A bundle's symbolic name
EVENT	Object	The actual event object. Used when rebroadcasting an event that was sent via some other event mechanism
EXCEPTION	Throwable	An exception or error
EXCEPTION_MESSAGE	String	Must be equal to the name of the Exception class.
EXCEPTION_CLASS	String	Must be equal to exception.getMessage()
MESSAGE	String	A human-readable message that is usually not localized.
SERVICE	ServiceReference	A service
SERVICE_ID	Long	A service's id
SERVICE_OBJECTCLASS	String[]	A service's objectClass
SERVICE_PID	String	A service's persistent identity
TIMESTAMP	Long	The time when the event occurred, as reported by System.currentTimeMillis()

The topic of an OSGi event is constructed by taking the fully qualified name of the event class, substituting a slash for every period, and appending a slash followed by the name of the constant that defines the event type. For example, the topic of

BundleEvent.STARTED

Event becomes

org/osgi/framework/BundleEvent/STARTED

If a type code for the event is unknown then the event must be ignored.

113.6.2

OSGi Events

In order to present a consistent view of all the events occurring in the system, the existing Framework-level events are mapped to the Event Admin's publish-subscribe model. This allows event subscribers to treat framework events exactly the same as other events.

The properties associated with the event depends on its class as outlined in the following sections.

113.6.3 Framework Event

Framework Events must be delivered asynchronously with a topic of:

`org/osgi/framework/FrameworkEvent/<event type>`

The following event types are supported:

STARTED
ERROR
PACKAGES_REFRESHED
STARTLEVEL_CHANGED
WARNING
INFO

Other events are ignored, no event will be send by the Event Admin. The following event properties must be set for a Framework Event.

- `event` – (FrameworkEvent) The original event object.

If the FrameworkEvent `getBundle` method returns a non-null value, the following fields must be set:

- `bundle.id` – (Long) The source's bundle id.
- `bundle.symbolicName` – (String) The source bundle's symbolic name. Only set if the bundle's symbolic name is not null.
- `bundle` – (Bundle) The source bundle.

If the FrameworkEvent `getThrowable` method returns a non- null value:

- `exception.class` – (String) The fully-qualified class name of the attached Exception.
- `exception.message` – (String) The message of the attached exception. Only set if the Exception message is not null.
- `exception` – (Throwable) The Exception returned by the `getThrowable` method.

113.6.4 Bundle Event

Framework Events must be delivered asynchronously with a topic of:

`org/osgi/framework/BundleEvent/<event type>`

The following event types are supported:

INSTALLED
STARTED
STOPPED
UPDATED
UNINSTALLED
RESOLVED
UNRESOLVED

Unknown events must be ignored.

The following event properties must be set for a Bundle Event. If listeners require synchronous delivery then they should register a Synchronous Bundle Listener with the Framework.

- `event` – (BundleEvent) The original event object.
- `bundle.id` – (Long) The source's bundle id.

- `bundle.symbolicName` – (String) The source bundle's symbolic name. Only set if the bundle's symbolic name is not null.
- `bundle` – (Bundle) The source bundle.

113.6.5 Service Event

Service Events must be delivered asynchronously with the topic:

`org.osgi/framework/ServiceEvent/<event type>`

The following event types are supported:

REGISTERED
MODIFIED
UNREGISTERING

Unknown events must be ignored.

- `event` – (BundleEvent) The original event object.
- `service` – (ServiceReference) The result of the `getServiceReference` method
- `service.id` – (Long) The service's ID.
- `service.pid` – (String) The service's persistent identity. Only set if not null.
- `service.objectClass` – (String[]) The service's object class.

113.6.6 Log Events

Log events must be delivered asynchronously under the topic:

`org.osgi/service/log/LogEntry/<event type>`

The logging level is used as event type:

LOG_ERROR
LOG_WARNING
LOG_INFO
LOG_DEBUG
LOG_OTHER (when event is not recognized)

The properties of a log event are:

- `bundle.id` – (Long) The source bundle's id.
- `bundle.symbolicName` – (String) The source bundle's symbolic name. Only set if not null.
- `bundle` – (Bundle) The source bundle.
- `log.level` – (Integer) The log level.
- `message` – (String) The log message.
- `timestamp` – (Long) The log entry's timestamp.
- `log.entry` – (LogEntry) The LogEntry object.

If the log entry has an associated Exception:

- `exception.class` – (String) The fully-qualified class name of the attached exception. Only set if the `getException` method returns a non-null value.
- `exception.message` – (String) The message of the attached Exception. Only set if the Exception message is not null.
- `exception` – (Throwable) The Exception returned by the `getException` method.

If the `getServiceReference` method returns a non-null value:

- `service` – (`ServiceReference`) The result of the `getServiceReference` method.
- `service.id` – (`Long`) The id of the service.
- `service.pid` – (`String`) The service's persistent identity. Only set if the `service.pid` service property is not null.
- `service.objectClass` – (`String[]`) The object class of the service object.

113.7 Event Admin Service

The Event Admin service must be registered as a service with the object class `org.osgi.service.event.EventAdmin`. Multiple Event Admin services can be registered. Publishers should publish their event on the Event Admin service with the highest value for the `SERVICE_RANKING` service property. This is the service selected by the `getServiceReference` method.

The Event Admin service is responsible for tracking the registered handlers, handling event notifications and providing at least one thread for asynchronous event delivery.

113.7.1 Synchronous Event Delivery

Synchronous event delivery is initiated by the `sendEvent` method. When this method is invoked, the Event Admin service determines which handlers must be notified of the event and then notifies each one in turn. The handlers can be notified in the caller's thread or in an event-delivery thread, depending on the implementation. In either case, all notifications must be completely handled before the `sendEvent` method returns to the caller.

Synchronous event delivery is significantly more expensive than asynchronous delivery. All things considered equal, the asynchronous delivery should be preferred over the synchronous delivery.

Callers of this method will need to be coded defensively and assume that synchronous event notifications could be handled in a separate thread. That entails that they must not be holding any monitors when they invoke the `sendEvent` method. Otherwise they significantly increase the likelihood of deadlocks because Java monitors are not reentrant from another thread by definition. Not holding monitors is good practice even when the event is dispatched in the same thread.

113.7.2 Asynchronous Event Delivery

Asynchronous event delivery is initiated by the `postEvent` method. When this method is invoked, the Event Admin service must determine which handlers are interested in the event. By collecting this list of handlers during the method invocation, the Event Admin service ensures that only handlers that were registered at the time the event was posted will receive the event notification.

The Event Admin service can use more than one thread to deliver events. If it does then it must guarantee that each handler receives the events in the same order as the events were posted. This ensures that handlers see events in the expected order. For example, it would be an error to see a destroyed event before the corresponding created event.

Before notifying each handler, the event delivery thread must ensure that the handler is still registered in the service registry. If it has been unregistered then the handler must not be notified.

The Event Admin service ensures that events are delivered in a well-defined order. For example, if a thread posts events A and B in the same thread then the handlers should not receive them in the order B, A. If A and B are posted by different threads at about the same time then no guarantees about the order of delivery are made.

113.7.3 Order of Event Delivery

Asynchronous events are delivered in the order in which they arrive in the event queue. Thus if two events are posted by the same thread then they will be delivered in the same order (though other events may come between them). However, if two or more events are posted by different threads then the order in which they arrive in the queue (and therefore the order in which they are delivered) will depend very much on subtle timing issues. The event delivery system cannot make any guarantees in this case.

Synchronous events are delivered as soon as they are sent. If two events are sent by the same thread, one after the other, then they must be guaranteed to be processed serially and in the same order. However, if two events are sent by different threads then no guarantees can be made. The events can be processed in parallel or serially, depending on whether or not the Event Admin service dispatches synchronous events in the caller's thread or in a separate thread.

Note that if the actions of a handler trigger a synchronous event, then the delivery of the first event will be paused and delivery of the second event will begin. Once delivery of the second event has completed, delivery of the first event will resume. Thus some handlers may observe the second event before they observe the first one.

113.8 Reliability

113.8.1 Exceptions in callbacks

If a handler throws an Exception during delivery of an event, it must be caught by the Event Admin service and handled in some implementation specific way. If a Log Service is available the exception should be logged. Once the exception has been caught and dealt with, the event delivery must continue with the next handlers to be notified, if any.

113.8.2 Dealing with Stalled Handlers

Event handlers should not spend too long in the `handleEvent` method. Doing so will prevent other handlers in the system from being notified. If a handler needs to do something that can take a while, it should do it in a different thread.

An event admin implementation can attempt to detect stalled or dead-locked handlers and deal with them appropriately. Exactly how it deals with this situation is left as implementation specific. One allowed implementation is to mark the current event delivery thread as invalid and spawn a new event delivery thread. Event delivery must resume with the next handler to be notified.

Implementations can choose to blacklist any handlers that they determine are misbehaving. Blacklisted handlers must not be notified of any events. If a handler is blacklisted, the event admin should log a message that explains the reason for it.

113.9 Inter-operability with Native Applications

Implementations of the Event Admin service can support passing events to, and/or receiving events from native applications.

If the implementation supports native inter-operability, it must be able to pass the topic of the event and its properties to/from native code. Implementations must be able to support property values of the following types:

- String objects, including full Unicode support
- Integer, Long, Byte, Short, Float, Double, Boolean, Character objects
- Single-dimension arrays of the above types (including String)
- Single-dimension arrays of Java's eight primitive types (int, long, byte, short, float, double, boolean, char)

Implementations can support additional types. Property values of unsupported types must be silently discarded.

113.10 Security

113.10.1 Topic Permission

The `TopicPermission` class allows fine-grained control over which bundles may post events to a given topic and which bundles may receive those events.

The target parameter for the permission is the topic name. `TopicPermission` classes uses a wildcard matching algorithm similar to the `BasicPermission` class, except that slashes are used as separators instead of periods. For example, a name of `a/b/*` implies `a/b/c` but not `x/y/z` or `a/b`.

There are two available actions: PUBLISH and SUBSCRIBE. These control a bundle's ability to either publish or receive events, respectively. Neither one implies the other.

113.10.2 Required Permissions

Bundles that need to register an event handler must be granted `ServicePermission[org.osgi.service.event.EventHandler, REGISTER]`. In addition, handlers require `TopicPermission[<topic>, SUBSCRIBE]` for each topic they want to be notified about.

Bundles that need to publish an event must be granted `ServicePermission[org.osgi.service.event.EventAdmin, GET]` so that they may retrieve the Event Admin service and use it. In addition, event sources require `TopicPermission[<topic>, PUBLISH]` for each topic they want to send events to.

Bundles that need to iterate the handlers registered with the system must be granted `ServicePermission[org.osgi.service.event.EventHandler, GET]` to retrieve the event handlers from the service registry.

Only a bundle that contains an Event Admin service implementation should be granted `ServicePermission[org.osgi.service.event.EventAdmin, REGISTER]` to register the event channel admin service.

113.10.3 Security Context During Event Callbacks

During an event notification, the Event Admin service's Protection Domain will be on the stack above the handler's Protection Domain. In the case of a synchronous event, the event publisher's protection domain can also be on the stack.

Therefore, if a handler needs to perform a secure operation using its own privileges, it must invoke the `doPrivileged` method to isolate its security context from that of its caller.

The event delivery mechanism must not wrap event notifications in a `doPrivileged` call.

113.11 org.osgi.service.event

The OSGi Event Admin Specification Version 1.0.

Bundles wishing to use this package must list the package in the `Import-Package` header of the bundle's manifest. For example:

`Import-Package: org.osgi.service.event; version=1.0`

113.11.1 Summary

- Event - An event. [p.326]
- EventAdmin - The Event Admin service. [p.326]
- EventConstants - Defines standard names for EventHandler properties. [p.327]
- EventHandler - Listener for Events. [p.328]
- TopicPermission - A bundle's authority to publish or subscribe to event on a topic. [p.329]

113.11.2 public class Event

An event. Event objects are delivered to EventHandler services which subscribe to the topic of the event.

113.11.2.1 public Event(String topic, Dictionary properties)

topic The topic of the event.

properties The event's properties (may be null).

- Constructs an event.

Throws IllegalArgumentException – If topic is not a valid topic name.

113.11.2.2 public boolean equals(Object object)

object The Event object to be compared.

- Compares this Event object to another object.

An event is considered to be **equal to** another event if the topic is equal and the properties are equal.

Returns true if object is a Event and is equal to this object; false otherwise.

113.11.2.3 public final Object getProperty(String name)

name the name of the property to retrieve

- Retrieves a property.

Returns The value of the property, or null if not found.

113.11.2.4 public final String[] getPropertyNames()

- Returns a list of this event's property names.

Returns A non-empty array with one element per property.

113.11.2.5 public final String getTopic()

- Returns the topic of this event.

Returns The topic of this event.

113.11.2.6 public int hashCode()

- Returns a hash code value for the object.

Returns An integer which is a hash code value for this object.

113.11.2.7 public final boolean matches(Filter filter)

filter The filter to test.

- Tests this event's properties against the given filter.

Returns true If this event's properties match the filter, false otherwise.

113.11.2.8 public String toString()

- Returns the string representation of this event.

Returns The string representation of this event.

113.11.3 public interface EventAdmin

The Event Admin service. Bundles wishing to publish events must obtain the Event Admin service and call one of the event delivery methods.

113.11.3.1 public void postEvent(Event event)

event The event to send to all listeners which subscribe to the topic of the event.

- Initiate asynchronous delivery of an event. This method returns to the caller before delivery of the event is completed.

Throws `SecurityException` – If the caller does not have `TopicPermission[topic, PUBLISH]` for the topic specified in the event.

113.11.3.2 public void sendEvent(Event event)

event The event to send to all listeners which subscribe to the topic of the event.

- Initiate synchronous delivery of an event. This method does not return to the caller until delivery of the event is completed.

Throws `SecurityException` – If the caller does not have `TopicPermission[topic, PUBLISH]` for the topic specified in the event.

113.11.4 public interface EventConstants

Defines standard names for `EventHandler` properties.

113.11.4.1 public static final String BUNDLE_SIGNER = “bundle.signer”

The Distinguished Name of the bundle relevant to the event.

113.11.4.2 public static final String BUNDLE_SYMBOLICNAME = “bundle.symbolicName”

The Bundle Symbolic Name of the bundle relevant to the event.

113.11.4.3 public static final String EVENT = “event”

The actual event object. Used when rebroadcasting an event that was sent via some other event mechanism.

113.11.4.4 public static final String EVENT_FILTER = “event.filter”

Service Registration property (named `event.filter`) specifying a filter to further select Events of interest to a Event Handler service.

Event handlers MAY be registered with this property. The value of this property is a string containing an LDAP-style filter specification. Any of the event's properties may be used in the filter expression. Each event handler is notified for any event which belongs to the topics in which the handler has expressed an interest. If the event handler is also registered with this service property, then the properties of the event must also match the filter for the event to be delivered to the event handler.

If the filter syntax is invalid, then the Event Handler must be ignored and a warning should be logged.

See Also `Event[p.326]`, `org.osgi.framework.Filter`

-
- 113.11.4.5** **public static final String EVENT_TOPIC = "event.topics"**
- Service registration property (named event.topic) specifying the Event topics of interest to a Event Handler service.
- Event handlers SHOULD be registered with this property. The value of the property is an array of strings that describe the topics in which the handler is interested. An asterisk (*) may be used as a trailing wildcard. Event handlers which do not have a value for this property are treated as though they had specified this property with the value { '*' }. More precisely, the value of each entry in the array must conform to the following grammar:
- ```

 topic-description := '*' | topic ('/' '*')?
 topic := token ('/' token)*
```
- See Also* Event[p.326]
- 113.11.4.6**      **public static final String EXCEPTION = "exception"**
- An exception or error.
- 113.11.4.7**      **public static final String EXCEPTION\_MESSAGE = "exception.message"**
- Must be equal to exception.getMessage()
- 113.11.4.8**      **public static final String EXCEPTION\_CLASS = "exception.class"**
- Must be equal to the name of the Exception class.
- 113.11.4.9**      **public static final String MESSAGE = "message"**
- A human-readable message that is usually not localized.
- 113.11.4.10**      **public static final String SERVICE = "service"**
- A service
- 113.11.4.11**      **public static final String SERVICE\_ID = "service.id"**
- A service's id.
- 113.11.4.12**      **public static final String SERVICE\_OBJECTCLASS = "service.objectClass"**
- A service's objectClass
- 113.11.4.13**      **public static final String SERVICE\_PID = "service.pid"**
- A service's persistent identity.
- 113.11.4.14**      **public static final String TIMESTAMP = "timestamp"**
- The time when the event occurred, as reported by System.currentTimeMillis()
- 113.11.5**      **public interface EventHandler**
- Listener for Events.
- EventHandler objects are registered with the Framework service registry and are notified with an Event object when an event is sent or posted.
-

EventHandler objects can inspect the received Event object to determine its topic and properties.

EventHandler objects must be registered with a service property `EventConstants.EVENT_TOPIC`[p.327] whose value is the list of topics in which the event handler is interested.

For example:

```
String[] topics = new String[] {EventConstants.EVENT_TOPIC,
"com/issv/*"};
Hashtable ht = new Hashtable();
ht.put(EVENT_TOPIC, topics);
context.registerService(EventHandler.class.getName(), this,
ht);
```

Event Handler services can also be registered with an `@link EventConstants#EVENT_FILTER` service property to further filter the events. If the syntax of this filter is invalid, then the Event Handler must be ignored by the Event Admin service. The Event Admin service should log a warning.

Security Considerations. Bundles wishing to monitor Event objects will require `ServicePermission[EventHandler,REGISTER]` to register an EventHandler service. The bundle must also have `TopicPermission[topic, SUBSCRIBE]` for the topic specified in the event in order to receive the event.

See Also `Event`[p.326]

#### 113.11.5.1 **public void handleEvent( Event event )**

*event* The event that occurred.

- Called by the `EventAdmin`[p.326] service to notify the listener of an event.

### 113.11.6 **public final class TopicPermission extends Permission**

A bundle's authority to publish or subscribe to event on a topic.

A topic is a slash-separated string that defines a topic.

For example:

```
org.osgi/service/foo/FooEvent/ACTION
```

`TopicPermission` has two actions: publish and subscribe.

#### 113.11.6.1 **public static final String PUBLISH = "publish"**

The action string publish.

#### 113.11.6.2 **public static final String SUBSCRIBE = "subscribe"**

The action string subscribe.

#### 113.11.6.3 **public TopicPermission( String name, String actions )**

*name* Topic name.

*actions* publish,subscribe (canonical order).

- Defines the authority to publish and/or subscribe to a topic within the EventAdmin service.

The name is specified as a slash-separated string. Wildcards may be used. For example:

```
org/osgi/service/fooFooEvent/ACTION
com/isv/*
*
```

A bundle that needs to publish events on a topic must have the appropriate TopicPermission for that topic; similarly, a bundle that needs to subscribe to events on a topic must have the appropriate TopicPermssion for that topic.

#### 113.11.6.4 **public boolean equals( Object obj )**

*obj* The object to test for equality with this TopicPermission object.

- Determines the equality of two TopicPermission objects. This method checks that specified TopicPermission has the same topic name and actions as this TopicPermission object.

*Returns* true if obj is a TopicPermission, and has the same topic name and actions as this TopicPermission object; false otherwise.

#### 113.11.6.5 **public String getActions( )**

- Returns the canonical string representation of the TopicPermission actions. Always returns present TopicPermission actions in the following order: publish,subscribe.

*Returns* Canonical string representation of the TopicPermission actions.

#### 113.11.6.6 **public int hashCode( )**

- Returns the hash code value for this object.

*Returns* A hash code value for this object.

#### 113.11.6.7 **public boolean implies( Permission p )**

*p* The target permission to interrogate.

- Determines if the specified permission is implied by this object.

This method checks that the topic name of the target is implied by the topic name of this object. The list of TopicPermission actions must either match or allow for the list of the target object to imply the target TopicPermission action.

```
x/y/*, "publish" -> x/y/z, "publish" is true
*, "subscribe" -> x/y, "subscribe" is true
*, "publish" -> x/y, "subscribe" is false
x/y, "publish" -> x/y/z, "publish" is false
```

*Returns* true if the specified TopicPermission action is implied by this object; false otherwise.

#### 113.11.6.8 **public PermissionCollection newPermissionCollection( )**

- Returns a new PermissionCollection object suitable for storing TopicPermission objects.

*Returns* A new PermissionCollection object.



# 701 Service Tracker Specification

## Version 1.3

### 701.1 Introduction

The Framework provides a powerful and very dynamic programming environment. Bundles are installed, started, stopped, updated, and uninstalled without shutting down the Framework. Dependencies between bundles are monitored by the Framework, but bundles *must* cooperate in handling these dependencies correctly.

An important aspect of the Framework is the service registry. Bundle developers must be careful not to use service objects that have been unregistered. The dynamic nature of the Framework service registry makes it necessary to track the service objects as they are registered and unregistered. It is easy to overlook rare race conditions or boundary conditions that will lead to random errors.

An example of a potential problem is what happens when the initial list of services of a certain type is created when a bundle is started. When the `ServiceListener` object is registered before the Framework is asked for the list of services, without special precautions, duplicates can enter the list. When the `ServiceListener` object is registered after the list is made, it is possible to miss relevant events.

The specification defines a utility class, `ServiceTracker`, that makes tracking the registration, modification, and unregistration of services much easier. A `ServiceTracker` class can be customized by implementing the interface or by sub-classing the `ServiceTracker` class.

This utility specifies a class that significantly reduces the complexity of tracking services in the service registry.

#### 701.1.1 Essentials

- *Customizable* – Allow a default implementation to be customized so that bundle developers can start simply and later extend the implementation to meet their needs.
- *Small* – Every Framework implementation should have this utility implemented. It should therefore be very small because some Framework implementations target minimal OSGi Service Platforms.
- *Tracked set* – Track a single object defined by a `ServiceReference` object, all instances of a service, or any set specified by a filter expression.

#### 701.1.2 Operation

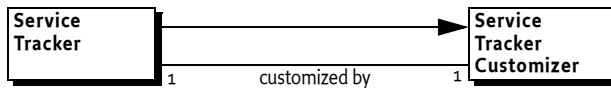
The fundamental tasks of a `ServiceTracker` object are:

- To create an initial list of services as specified by its creator.
- To listen to `ServiceEvent` instances so that services of interest to the owner are properly tracked.
- To allow the owner to customize the tracking process through programmatic selection of the services to be tracked, as well as to act when a service is added or removed.

A `ServiceTracker` object populates a set of services that match a given search criteria, and then listens to `ServiceEvent` objects which correspond to those services.

### 701.1.3 Entities

Figure 51 Class diagram of `org.osgi.util.tracker`



### 701.1.4 Prerequisites

This specification requires OSGi Framework version 1.1 or higher because the `ServiceTracker` uses the `Filter` class that was not available in version 1.0.

## 701.2 Service Tracker Class

The `ServiceTracker` interface defines three constructors to create `ServiceTracker` objects, each providing different search criteria:

- `ServiceTracker(BundleContext,String,ServiceTrackerCustomizer)` – This constructor takes a service interface name as the search criterion. The `ServiceTracker` object must then track all services that are registered under the specified service interface name.
- `ServiceTracker(BundleContext,Filter,ServiceTrackerCustomizer)` – This constructor uses a `Filter` object to specify the services to be tracked. The `ServiceTracker` must then track all services that match the specified filter.
- `ServiceTracker(BundleContext,ServiceReference,ServiceTrackerCustomizer)` – This constructor takes a `ServiceReference` object as the search criterion. The `ServiceTracker` must then track only the service that corresponds to the specified `ServiceReference`. Using this constructor, no more than one service must ever be tracked, because a `ServiceReference` refers to a specific service.

Each of the `ServiceTracker` constructors takes a `BundleContext` object as a parameter. This `BundleContext` object must be used by a `ServiceTracker` object to track, get, and unget services.

A new `ServiceTracker` object must not begin tracking services until its `open` method is called. There are 2 versions of the `open` method:

- `open()` – This method is identical to `open(false)`. It is provided for backward compatibility reasons.
- `open(boolean)` – The tracker must start tracking the services as were specified in its constructor. If the boolean parameter is `true`, it must track



all services, regardless if they are compatible with the bundle that created the Service Tracker or not. See Section 5.9 “Multiple Version Export Considerations” for a description of the compatibility issues when multiple variations of the same package can exist. If the parameter is `false`, the Service Tracker must only track compatible versions.

## 701.3 Using a Service Tracker

Once a `ServiceTracker` object is opened, it begins tracking services immediately. A number of methods are available to the bundle developer to monitor the services that are being tracked. The `ServiceTracker` class defines these methods:

- `getService()` – Returns one of the services being tracked or null if there are no active services being tracked.
- `getServices()` – Returns an array of all the tracked services. The number of tracked services is returned by the `size` method.
- `getServiceReference()` – Returns a `ServiceReference` object for one of the services being tracked. The service object for this service may be returned by calling the `ServiceTracker` object's `getService()` method.
- `getServiceReferences()` – Returns a list of the `ServiceReference` objects for services being tracked. The service object for a specific tracked service may be returned by calling the `ServiceTracker` object's `getService(ServiceReference)` method.
- `waitForService(long)` – Allows the caller to wait until at least one instance of a service is tracked or until the time-out expires. If the time-out is zero, the caller must wait until at least one instance of a service is tracked. `waitForService` must not be used within the `BundleActivator` methods, as these methods are expected to complete in a short period of time. A Framework could wait for the start method to complete before starting the bundle that registers the service for which the caller is waiting, creating a deadlock situation.
- `remove(ServiceReference)` – This method may be used to remove a specific service from being tracked by the `ServiceTracker` object, causing `removedService` to be called for that service.
- `close()` – This method must remove all services being tracked by the `ServiceTracker` object, causing `removedService` to be called for all tracked services.
- `getTrackingCount()` – A Service Tracker can have services added, modified, or removed at any moment in time. The `getTrackingCount` method is intended to efficiently detect changes in a Service Tracker. Every time the Service Tracker is changed, it must increase the tracking count. A method that processes changes in a Service Tracker could get the tracking count before it processes the changes. If the tracking count has changed at the end of the method, the method should be repeated because a new change occurred during processing.

## 701.4 Customizing the Service Tracker class

The behavior of the `ServiceTracker` class can be customized either by providing a `ServiceTrackerCustomizer` object implementing the desired behavior when the `ServiceTracker` object is constructed, or by sub-classing the `ServiceTracker` class and overriding the `ServiceTrackerCustomizer` methods.

The `ServiceTrackerCustomizer` interface defines these methods:

- `addingService(ServiceReference)` – Called whenever a service is being added to the `ServiceTracker` object.
- `modifiedService(ServiceReference,Object)` – Called whenever a tracked service is modified.
- `removedService(ServiceReference,Object)` – Called whenever a tracked service is removed from the `ServiceTracker` object.

When a service is being added to the `ServiceTracker` object or when a tracked service is modified or removed from the `ServiceTracker` object, it must call `addingService`, `modifiedService`, or `removedService`, respectively, on the `ServiceTrackerCustomizer` object (if specified when the `ServiceTracker` object was created); otherwise it must call these methods on itself.

A bundle developer may customize the action when a service is tracked. Another reason for customizing the `ServiceTracker` class is to programmatically select which services are tracked. A filter may not sufficiently specify the services that the bundle developer is interested in tracking. By implementing `addingService`, the bundle developer can use additional runtime information to determine if the service should be tracked. If null is returned by the `addingService` method, the service must not be tracked.

Finally, the bundle developer can return a specialized object from `addingService` that differs from the service object. This specialized object could contain the service object and any associated information. This returned object is then tracked instead of the service object. When the `removedService` method is called, the object that is passed along with the `ServiceReference` object is the one that was returned from the earlier call to the `addingService` method.

### 701.4.1 Symmetry

If sub-classing is used to customize the Service Tracker, care must be exercised in using the default implementations of the `addingService` and `removedService` methods. The `addingService` method will get the service and the `removedService` method assumes it has to unget the service. Overriding one and not the other may thus cause unexpected results.

## 701.5 Customizing Example

An example of customizing the action taken when a service is tracked might be registering a `Servlet` object with each `Http Service` that is tracked. This customization could be done by sub-classing the `ServiceTracker` class and overriding the `addingService` and `removedService` methods as follows:

```
public Object addingService(ServiceReference reference) {
 Object obj = context.getService(reference);
 HttpService svc = (HttpService)obj;
 // Register the Servlet using svc
 ...
 return svc;
}
public void removedService(ServiceReference reference,
 Object obj){
 HttpService svc = (HttpService)obj;
 // Unregister the Servlet using svc
 ...
 context.ungetService(reference);
}
```

## 701.6 Security

A ServiceTracker object contains a BundleContext instance variable that is accessible to the methods in a subclass. A BundleContext object should never be given to other bundles because it is used for security aspects of the Framework.

The ServiceTracker implementation does not have a method to get the BundleContext object but subclasses should be careful not to provide such a method if the ServiceTracker object is given to other bundles.

The services that are being tracked are available via a ServiceTracker. These services are dependent on the BundleContext as well. It is therefore necessary to do a careful security analysis when ServiceTracker objects are given to other bundles.

## 701.7 Changes

- The [open\(boolean\)](#) method was added to support Framework version 1.3.

## 701.8 org.osgi.util.tracker

The OSGi Service Tracker Package. Specification Version 1.3.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

Import-Package: org.osgi.util.tracker; version=1.3

### 701.8.1 Summary

- ServiceTracker - The ServiceTracker class simplifies using services from the Framework's service registry. [p.337]
- ServiceTrackerCustomizer - The ServiceTrackerCustomizer interface allows a ServiceTracker object to customize the service objects that are tracked. [p.342]

## 701.8.2 **public class ServiceTracker implements ServiceTrackerCustomizer**

The ServiceTracker class simplifies using services from the Framework's service registry.

A ServiceTracker object is constructed with search criteria and a ServiceTrackerCustomizer object. A ServiceTracker object can use the ServiceTrackerCustomizer object to customize the service objects to be tracked. The ServiceTracker object can then be opened to begin tracking all services in the Framework's service registry that match the specified search criteria. The ServiceTracker object correctly handles all of the details of listening to ServiceEvent objects and getting and ungetting services.

The getServiceReferences method can be called to get references to the services being tracked. The getService and getServices methods can be called to get the service objects for the tracked service.

### 701.8.2.1 **protected final BundleContext context**

Bundle context this ServiceTracker object is tracking against.

### 701.8.2.2 **protected final Filter filter**

Filter specifying search criteria for the services to track.

*Since* 1.1

### 701.8.2.3 **public ServiceTracker( BundleContext context, ServiceReference reference, ServiceTrackerCustomizer customizer )**

*context* BundleContext object against which the tracking is done.

*reference* ServiceReference object for the service to be tracked.

*customizer* The customizer object to call when services are added, modified, or removed in this ServiceTracker object. If customizer is null, then this ServiceTracker object will be used as the ServiceTrackerCustomizer object and the ServiceTracker object will call the ServiceTrackerCustomizer methods on itself.

- Create a ServiceTracker object on the specified ServiceReference object.  
The service referenced by the specified ServiceReference object will be tracked by this ServiceTracker object.

### 701.8.2.4 **public ServiceTracker( BundleContext context, String clazz, ServiceTrackerCustomizer customizer )**

*context* BundleContext object against which the tracking is done.

*clazz* Class name of the services to be tracked.

*customizer* The customizer object to call when services are added, modified, or removed in this ServiceTracker object. If customizer is null, then this ServiceTracker object will be used as the ServiceTrackerCustomizer object and the ServiceTracker object will call the ServiceTrackerCustomizer methods on itself.

- Create a ServiceTracker object on the specified class name.  
Services registered under the specified class name will be tracked by this ServiceTracker object.

**701.8.2.5      public ServiceTracker( BundleContext context, Filter filter, ServiceTrackerCustomizer customizer )**

*context* BundleContext object against which the tracking is done.

*filter* Filter object to select the services to be tracked.

*customizer* The customizer object to call when services are added, modified, or removed in this ServiceTracker object. If customizer is null, then this ServiceTracker object will be used as the ServiceTrackerCustomizer object and the ServiceTracker object will call the ServiceTrackerCustomizer methods on itself.

- Create a ServiceTracker object on the specified Filter object.

Services which match the specified Filter object will be tracked by this ServiceTracker object.

*Since* 1.1

**701.8.2.6      public Object addingService( ServiceReference reference )**

*reference* Reference to service being added to this ServiceTracker object.

- Default implementation of the ServiceTrackerCustomizer.addingService method.

This method is only called when this ServiceTracker object has been constructed with a null ServiceTrackerCustomizer argument. The default implementation returns the result of calling getService, on the BundleContext object with which this ServiceTracker object was created, passing the specified ServiceReference object.

This method can be overridden in a subclass to customize the service object to be tracked for the service being added. In that case, take care not to rely on the default implementation of removedService that will unget the service.

*Returns* The service object to be tracked for the service added to this ServiceTracker object.

*See Also* ServiceTrackerCustomizer[p.342]

**701.8.2.7      public synchronized void close( )**

- Close this ServiceTracker object.

This method should be called when this ServiceTracker object should end the tracking of services.

**701.8.2.8      protected void finalize( ) throws Throwable**

- Finalize. This method no longer performs any function but it kept to maintain binary compatibility with prior versions of this class.

**701.8.2.9      public Object getService( ServiceReference reference )**

*reference* Reference to the desired service.

- Returns the service object for the specified ServiceReference object if the referenced service is being tracked by this ServiceTracker object.

*Returns* Service object or null if the service referenced by the specified ServiceReference object is not being tracked.

**701.8.2.10      public Object getService( )**

- Returns a service object for one of the services being tracked by this ServiceTracker object.

If any services are being tracked, this method returns the result of calling `getService(getServiceReference())`.

*Returns* Service object or null if no service is being tracked.

**701.8.2.11      public ServiceReference getServiceReference( )**

- Returns a ServiceReference object for one of the services being tracked by this ServiceTracker object.

If multiple services are being tracked, the service with the highest ranking (as specified in its `service.ranking` property) is returned.

If there is a tie in ranking, the service with the lowest service ID (as specified in its `service.id` property); that is, the service that was registered first is returned.

This is the same algorithm used by `BundleContext.getServiceReference`.

*Returns* ServiceReference object or null if no service is being tracked.

*Since* 1.1

**701.8.2.12      public ServiceReference[] getServiceReferences( )**

- Return an array of ServiceReference objects for all services being tracked by this ServiceTracker object.

*Returns* Array of ServiceReference objects or null if no service are being tracked.

**701.8.2.13      public Object[] getServices( )**

- Return an array of service objects for all services being tracked by this ServiceTracker object.

*Returns* Array of service objects or null if no service are being tracked.

**701.8.2.14      public int getTrackingCount( )**

- Returns the tracking count for this ServiceTracker object. The tracking count is initialized to 0 when this ServiceTracker object is opened. Every time a service is added or removed from this ServiceTracker object the tracking count is incremented.

The tracking count can be used to determine if this ServiceTracker object has added or removed a service by comparing a tracking count value previously collected with the current tracking count value. If the value has not changed, then no service has been added or removed from this ServiceTracker object since the previous tracking count was collected.

*Returns* The tracking count for this ServiceTracker object or -1 if this ServiceTracker object is not open.

*Since* 1.2

**701.8.2.15      public void modifiedService( ServiceReference reference, Object service )**

*reference* Reference to modified service.

*service* The service object for the modified service.

- ❑ Default implementation of the `ServiceTrackerCustomizer.modifiedService` method.

This method is only called when this `ServiceTracker` object has been constructed with a null `ServiceTrackerCustomizer` argument. The default implementation does nothing.

*See Also* `ServiceTrackerCustomizer`[p.342]

#### **701.8.2.16      public void open( )**

- ❑ Open this `ServiceTracker` object and begin tracking services.

This method calls `open(false)`.

*Throws* `IllegalStateException` – if the `BundleContext` object with which this `ServiceTracker` object was created is no longer valid.

*See Also* `open(boolean)` [p.341]

#### **701.8.2.17      public synchronized void open( boolean trackAllServices )**

*trackAllServices* If true, then this `ServiceTracker` will track all matching services regardless of class loader accessibility. If false, then this `ServiceTracker` will only track matching services which are class loader accessible to the bundle whose `BundleContext` is used by this `ServiceTracker`.

- ❑ Open this `ServiceTracker` object and begin tracking services.

Services which match the search criteria specified when this `ServiceTracker` object was created are now tracked by this `ServiceTracker` object.

*Throws* `IllegalStateException` – if the `BundleContext` object with which this `ServiceTracker` object was created is no longer valid.

*Since* 1.3

#### **701.8.2.18      public void remove( ServiceReference reference )**

*reference* Reference to the service to be removed.

- ❑ Remove a service from this `ServiceTracker` object. The specified service will be removed from this `ServiceTracker` object. If the specified service was being tracked then the `ServiceTrackerCustomizer.removedService` method will be called for that service.

#### **701.8.2.19      public void removedService( ServiceReference reference, Object service )**

*reference* Reference to removed service.

*service* The service object for the removed service.

- ❑ Default implementation of the `ServiceTrackerCustomizer.removedService` method.

This method is only called when this `ServiceTracker` object has been constructed with a null `ServiceTrackerCustomizer` argument. The default implementation calls `ungetService`, on the `BundleContext` object with which this `ServiceTracker` object was created, passing the specified `ServiceReference` object.

This method can be overridden in a subclass. If the default implementation of addingService method was used, this method must unget the service.

*See Also* ServiceTrackerCustomizer[p.342]

#### **701.8.2.20      public int size( )**

- Return the number of services being tracked by this ServiceTracker object.

*Returns* Number of services being tracked.

#### **701.8.2.21      public Object waitForService( long timeout ) throws InterruptedException**

*timeout* time interval in milliseconds to wait. If zero, the method will wait indefinitely.

- Wait for at least one service to be tracked by this ServiceTracker object.

It is strongly recommended that waitForService is not used during the calling of the BundleActivator methods. BundleActivator methods are expected to complete in a short period of time.

*Returns* Returns the result of getService().

*Throws* InterruptedException – If another thread has interrupted the current thread.

IllegalArgumentException – If the value of timeout is negative.

### **701.8.3      public interface ServiceTrackerCustomizer**

The ServiceTrackerCustomizer interface allows a ServiceTracker object to customize the service objects that are tracked. The ServiceTrackerCustomizer object is called when a service is being added to the ServiceTracker object. The ServiceTrackerCustomizer can then return an object for the tracked service. The ServiceTrackerCustomizer object is also called when a tracked service is modified or has been removed from the ServiceTracker object.

The methods in this interface may be called as the result of a ServiceEvent being received by a ServiceTracker object. Since ServiceEvent s are synchronously delivered by the Framework, it is highly recommended that implementations of these methods do not register (BundleContext.registerService), modify ( ServiceRegistration.setProperties) or unregister ( ServiceRegistration.unregister) a service while being synchronized on any object.

#### **701.8.3.1      public Object addingService( ServiceReference reference )**

*reference* Reference to service being added to the ServiceTracker object.

- A service is being added to the ServiceTracker object.

This method is called before a service which matched the search parameters of the ServiceTracker object is added to it. This method should return the service object to be tracked for this ServiceReference object. The returned service object is stored in the ServiceTracker object and is available from the getService and getServices methods.



*Returns* The service object to be tracked for the ServiceReference object or null if the ServiceReference object should not be tracked.

**701.8.3.2      public void modifiedService( ServiceReference reference, Object service )**

*reference* Reference to service that has been modified.

*service* The service object for the modified service.

- A service tracked by the ServiceTracker object has been modified.

This method is called when a service being tracked by the ServiceTracker object has had its properties modified.

**701.8.3.3      public void removedService( ServiceReference reference, Object service )**

*reference* Reference to service that has been removed.

*service* The service object for the removed service.

- A service tracked by the ServiceTracker object has been removed.

This method is called after a service is no longer being tracked by the ServiceTracker object.



# 702 XML Parser Service Specification

## Version 1.0

### 702.1 Introduction

The Extensible Markup Language (XML) has become a popular method of describing data. As more bundles use XML to describe their data, a common XML Parser becomes necessary in an embedded environment in order to reduce the need for space. Not all XML Parsers are equivalent in function, however, and not all bundles have the same requirements on an XML parser.

This problem was addressed in the Java API for XML Processing, see [58] *JAXP* for Java 2 Standard Edition and Enterprise Edition. This specification addresses how the classes defined in JAXP can be used in an OSGi Service Platform. It defines how:

- Implementations of XML parsers can become available to other bundles
- Bundles can find a suitable parser
- A standard parser in a JAR can be transformed to a bundle

#### 702.1.1

### Essentials

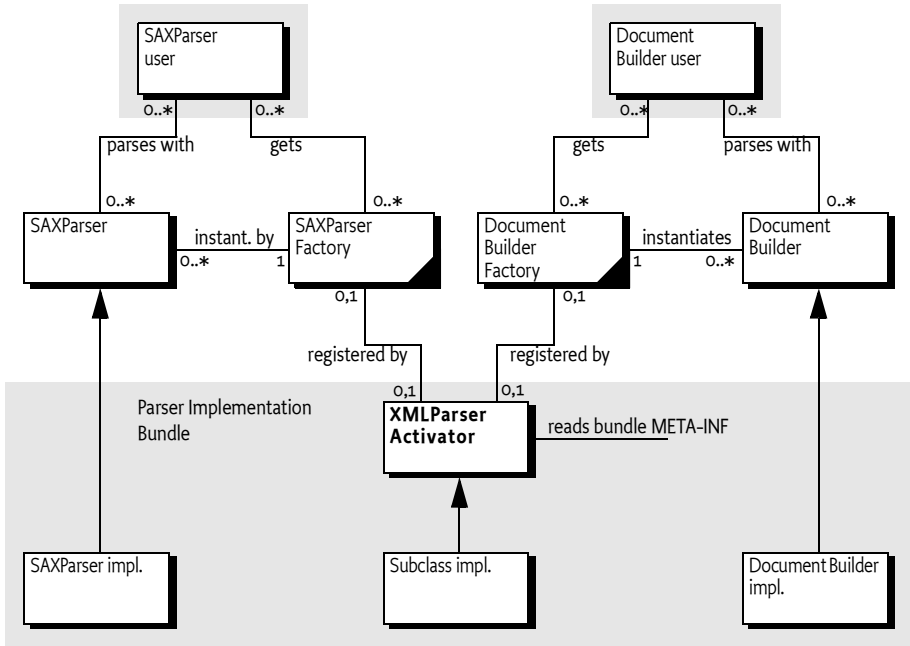
- *Standards* – Leverage existing standards in Java based XML parsing: JAXP, SAX and DOM
- *Unmodified JAXP code* – Run unmodified JAXP code
- *Simple* – It should be easy to provide a SAX or DOM parser as well as easy to find a matching parser
- *Multiple* – It should be possible to have multiple implementations of parsers available
- *Extendable* – It is likely that parsers will be extended in the future with more functionality

#### 702.1.2

### Entities

- *XMLParserActivator* – A utility class that registers a parser factory from declarative information in the Manifest file.
- *SAXParserFactory* – A class that can create an instance of a SAXParser class.
- *DocumentBuilderFactory* – A class that can create an instance of a DocumentBuilder class.
- *SAXParser* – A parser, instantiated by a SaxParserFactory object, that parses according to the SAX specifications.
- *DocumentBuilder* – A parser, instantiated by a DocumentBuilderFactory, that parses according to the DOM specifications.

Figure 52 XML Parsing diagram



### 702.1.3 Operations

A bundle containing a SAX or DOM parser is started. This bundle registers a `SAXParserFactory` and/or a `DocumentBuilderFactory` service object with the Framework. Service registration properties describe the features of the parsers to other bundles. A bundle that needs an XML parser will get a `SAXParserFactory` or `DocumentBuilderFactory` service object from the Framework service registry. This object is then used to instantiate the requested parsers according to their specifications.

## 702.2 JAXP

XML has become very popular in the last few years because it allows the interchange of complex information between different parties. Though only a single XML standard exists, there are multiple APIs to XML parsers, primarily of two types:

- The Simple API for XML (SAX1 and SAX2)
- Based on the Document Object Model (DOM 1 and 2)

Both standards, however, define an abstract API that can be implemented by different vendors.

A given XML Parser implementation may support either or both of these parser types by implementing the `org.w3c.dom` and/or `org.xml.sax` packages. In addition, parsers have characteristics such as whether they are validating or non-validating parsers and whether or not they are name-space aware.

An application which uses a specific XML Parser must code to that specific parser and become coupled to that specific implementation. If the parser has implemented [58] JAXP, however, the application developer can code against SAX or DOM and let the runtime environment decide which parser implementation is used.

JAXP uses the concept of a *factory*. A factory object is an object that abstracts the creation of another object. JAXP defines a `DocumentBuilderFactory` and a `SAXParserFactory` class for this purpose.

JAXP is implemented in the `javax.xml.parsers` package and provides an abstraction layer between an application and a specific XML Parser implementation. Using JAXP, applications can choose to use any JAXP compliant parser without changing any code, simply by changing a System property which specifies the SAX- and DOM factory class names.

In JAXP, the default factory is obtained with a static method in the `SAXParserFactory` or `DocumentBuilderFactory` class. This method will inspect the associated System property and create a new instance of that class.

## 702.3 XML Parser service

The current specification of JAXP has the limitation that only one of each type of parser factories can be registered. This specification specifies how multiple `SAXParserFactory` objects and `DocumentBuilderFactory` objects can be made available to bundles simultaneously.

Providers of parsers should register a JAXP factory object with the OSGi service registry under the factory class name. Service properties are used to describe whether the parser:

- Is validating
- Is name-space aware
- Has additional features

With this functionality, bundles can query the OSGi service registry for parsers supporting the specific functionality that they require.

## 702.4 Properties

Parsers must be registered with a number of properties that qualify the service. In this specification, the following properties are specified:

- **PARSER\_NAMESPACEAWARE** – The registered parser is aware of name-spaces. Name-spaces allow an XML document to consist of independently developed DTDs. In an XML document, they are recognized by the `xmlns` attribute and names prefixed with an abbreviated name-space identifier, like: `<xsl:if ...>`. The type is a Boolean object that must be true when the parser supports name-spaces. All other values, or the absence of the property, indicate that the parser does not implement name-spaces.
- **PARSER\_VALIDATING** – The registered parser can read the DTD and can validate the XML accordingly. The type is a Boolean object that must

true when the parser is validating. All other values, or the absence of the property, indicate that the parser does not validate.

## 702.5 Getting a Parser Factory

Getting a parser factory requires a bundle to get the appropriate factory from the service registry. In a simple case in which a non-validating, non-name-space aware parser would suffice, it is best to use `getServiceReference(String)`.

```
DocumentBuilder getParser(BundleContext context)
 throws Exception {
 ServiceReference ref = context.getServiceReference(
 DocumentBuilderFactory.class.getName());
 if (ref == null)
 return null;
 DocumentBuilderFactory factory =
 (DocumentBuilderFactory) context.getService(ref);
 return factory.newDocumentBuilder();
}
```

In a more demanding case, the filtered version allows the bundle to select a parser that is validating and name-space aware:

```
SAXParser getParser(BundleContext context)
 throws Exception {
 ServiceReference refs[] = context.getServiceReferences(
 SAXParserFactory.class.getName(),
 "(&(parser.namespaceAware=true)"
 + "(parser.validating=true))");
 if (refs == null)
 return null;
 SAXParserFactory factory =
 (SAXParserFactory) context.getService(refs[0]);
 return factory.newSAXParser();
}
```

## 702.6 Adapting a JAXP Parser to OSGi

If an XML Parser supports JAXP, then it can be converted to an OSGi aware bundle by adding a `BundleActivator` class which registers an XML Parser Service. The utility `org.osgi.util.xml.XMLParserActivator` class provides this function and can be added (copied, not referenced) to any XML Parser bundle, or it can be extended and customized if desired.

**702.6.1****JAR Based Services**

Its functionality is based on the definition of the [59] *JAR File specification, services directory*. This specification defines a concept for service providers. A JAR file can contain an implementation of an abstractly defined service. The class (or classes) implementing the service are designated from a file in the META-INF/services directory. The name of this file is the same as the abstract service class.

The content of the UTF-8 encoded file is a list of class names separated by new lines. White space is ignored and the number sign ('#' or '\u0023') is the comment character.

JAXP uses this service provider mechanism. It is therefore likely that vendors will place these service files in the META-INF/services directory.

**702.6.2****XMLParserActivator**

To support this mechanism, the XML Parser service provides a utility class that should be normally delivered with the OSGi Service Platform implementation. This class is a Bundle Activator and must start when the bundle is started. This class is copied into the parser bundle, and *not* imported.

The start method of the utility BundleActivator class will look in the META-INF/services service provider directory for the files `javax.xml.parsers.SAXParserFactory` ([SAXFACTORYNAME](#)) or `javax.xml.parsers.DocumentBuilderFactory` ([DOMFACTORYNAME](#)). The full path name is specified in the constants [SAXCLASSFILE](#) and [DOMCLASSFILE](#) respectively.

If either of these files exist, the utility BundleActivator class will parse the contents according to the specification. A service provider file can contain multiple class names. Each name is read and a new instance is created. The following example shows the possible content of such a file:

```
ACME example SAXParserFactory file
com.acme.saxparser.SAXParserFast # Fast
com.acme.saxparser.SAXParserValidating # Validates
```

Both the `javax.xml.parsers.SAXParserFactory` and the `javax.xml.parsers.DocumentBuilderFactory` provide methods that describe the features of the parsers they can create. The XMLParserActivator activator will use these methods to set the values of the properties, as defined in *Properties* on page 347, that describe the instances.

**702.6.3****Adapting an Existing JAXP Compatible Parser**

To incorporate this bundle activator into a XML Parser Bundle, do the following:

- If SAX parsing is supported, create a `/META-INF/services/javax.xml.parsers.SAXParserFactory` resource file containing the class names of the `SAXParserFactory` classes.
- If DOM parsing is supported, create a `/META-INF/services/javax.xml.parsers.DocumentBuilderFactory` file containing the fully qualified class names of the `DocumentBuilderFactory` classes.

- Create manifest file which imports the packages `org.w3c.dom`, `org.xml.sax`, and `javax.xml.parsers`.
- Add a `Bundle-Activator` header to the manifest pointing to the `XMLParserActivator`, the sub-class that was created, or a fully custom one.
- If the parsers support attributes, properties, or features that should be registered as properties so they can be searched, extend the `XMLParserActivator` class and override `setSAXProperties(javax.xml.parsers.SAXParserFactory,Hashtable)` and `setDOMProperties(javax.xml.parsers.DocumentBuilderFactory,Hashtable)`.
- Ensure that custom properties are put into the `Hashtable` object. JAXP does not provide a way for `XMLParserActivator` to query the parser to find out what properties were added.
- Bundles that extend the `XMLParserActivator` class must call the original methods via `super` to correctly initialize the XML Parser Service properties.
- Compile this class into the bundle.
- Install the new XML Parser Service bundle.
- Ensure that the `org.osgi.util.xml.XMLParserActivator` class is contained in the bundle.

# 702.7 Usage of JAXP

A single bundle should export the JAXP, SAX, and DOM APIs. The version of contained packages must be appropriately labeled. JAXP 1.1 or later is required which references SAX 2 and DOM 2. See [58] *JAXP* for the exact version dependencies.

This specification is related to related packages as defined in the JAXP 1.1 document. Table 24 contains the expected minimum versions.

Table 24 JAXP 1.1 minimum package versions

| Package             | Minimum Version |
|---------------------|-----------------|
| javax.xml.parsers   | 1.1             |
| org.xml.sax         | 2.0             |
| org.xml.sax.helpers | 2.0             |
| org.xml.sax.ext     | 1.0             |
| org.w3c.dom         | 2.0             |

The Xerces project from the Apache group, [60] *Xerces 2 Java Parser*, contains a number libraries that implement the necessary APIs. These libraries can be wrapped in a bundle to provide the relevant packages.



## 702.8 Security

A centralized XML parser is likely to see sensitive information from other bundles. Provisioning an XML parser should therefore be limited to trusted bundles. This security can be achieved by providing `ServicePermission[javax.xml.parsers.DocumentBuilderFactory | javax.xml.parsers.SAXFactory, REGISTER]` to only trusted bundles.

Using an XML parser is a common function, and `ServicePermission[javax.xml.parsers.DOMParserFactory | javax.xml.parsers.SAXFactory, GET]` should not be restricted.

The XML parser bundle will need `FilePermission[<<ALL FILES>>, READ]` for parsing of files because it is not known beforehand where those files will be located. This requirement further implies that the XML parser is a system bundle that must be fully trusted.

## 702.9 org.osgi.util.xml

The OSGi XML Parser service Package. Specification Version 1.0.

### 702.9.1 **public class XMLParserActivator implements BundleActivator , ServiceFactory**

A `BundleActivator` class that allows any JAXP compliant XML Parser to register itself as an OSGi parser service. Multiple JAXP compliant parsers can concurrently register by using this `BundleActivator` class. Bundles who wish to use an XML parser can then use the framework's service registry to locate available XML Parsers with the desired characteristics such as validating and namespace-aware.

The services that this bundle activator enables a bundle to provide are:

- `javax.xml.parsers.SAXParserFactory(SAXFACTORYNAME[p.352])`
- `javax.xml.parsers.DocumentBuilderFactory(DOMFACTORYNAME[p.352])`

The algorithm to find the implementations of the abstract parsers is derived from the JAR file specifications, specifically the Services API.

An `XMLParserActivator` assumes that it can find the class file names of the factory classes in the following files:

- `/META-INF/services/javax.xml.parsers.SAXParserFactory` is a file contained in a jar available to the runtime which contains the implementation class name(s) of the `SAXParserFactory`.
- `/META-INF/services/javax.xml.parsers.DocumentBuilderFactory` is a file contained in a jar available to the runtime which contains the implementation class name(s) of the `DocumentBuilderFactory`

If either of the files does not exist, `XMLParserActivator` assumes that the parser does not support that parser type.

XMLParserActivator attempts to instantiate both the SAXParserFactory and the DocumentBuilderFactory. It registers each factory with the framework along with service properties:

- `PARSER_VALIDATING`[p.352] - indicates if this factory supports validating parsers. It's value is a Boolean.
- `PARSER_NAMESPACEAWARE`[p.352] - indicates if this factory supports namespace aware parsers. Its value is a Boolean.

Individual parser implementations may have additional features, properties, or attributes which could be used to select a parser with a filter. These can be added by extending this class and overriding the `setSAXProperties` and `setDOMProperties` methods.

**702.9.1.1**      **public static final String DOMCLASSFILE = "/META-INF/services/javax.xml.parsers.DocumentBuilderFactory"**

Fully qualified path name of DOM Parser Factory Class Name file

**702.9.1.2**      **public static final String DOMFACTORYNAME = "javax.xml.parsers.DocumentBuilderFactory"**

Filename containing the DOM Parser Factory Class name. Also used as the basis for the `SERVICE_PID` registration property.

**702.9.1.3**      **public static final String PARSER\_NAMESPACEAWARE = "parser.namespaceAware"**

Service property specifying if factory is configured to support namespace aware parsers. The value is of type Boolean.

**702.9.1.4**      **public static final String PARSER\_VALIDATING = "parser.validating"**

Service property specifying if factory is configured to support validating parsers. The value is of type Boolean.

**702.9.1.5**      **public static final String SAXCLASSFILE = "/META-INF/services/javax.xml.parsers.SAXParserFactory"**

Fully qualified path name of SAX Parser Factory Class Name file

**702.9.1.6**      **public static final String SAXFACTORYNAME = "javax.xml.parsers.SAXParserFactory"**

Filename containing the SAX Parser Factory Class name. Also used as the basis for the `SERVICE_PID` registration property.

**702.9.1.7**      **public XMLParserActivator( )**

**702.9.1.8**      **public Object getService( Bundle bundle, ServiceRegistration registration )**

*bundle*      The bundle using the service.

*registration*      The ServiceRegistration object for the service.

- Creates a new XML Parser Factory object.

A unique XML Parser Factory object is returned for each call to this method.

The returned XML Parser Factory object will be configured for validating and namespace aware support as specified in the service properties of the specified ServiceRegistration object. This method can be overridden to configure additional features in the returned XML Parser Factory object.

*Returns* A new, configured XML Parser Factory object or null if a configuration error was encountered

**702.9.1.9      public void setDOMProperties( DocumentBuilderFactory factory, Hashtable props )**

*factory* - the DocumentBuilderFactory object

*props* - Hashtable of service properties.

- Set the customizable DOM Parser Service Properties.

This method attempts to instantiate a validating parser and a namespaceaware parser to determine if the parser can support those features. The appropriate properties are then set in the specified props object.

This method can be overridden to add additional DOM2 features and properties. If you want to be able to filter searches of the OSGi service registry, this method must put a key, value pair into the properties object for each feature or property. For example, `properties.put("http://www.acme.com/features/foo", Boolean.TRUE);`

**702.9.1.10      public void setSAXProperties( SAXParserFactory factory, Hashtable properties )**

*factory* - the SAXParserFactory object

*properties* - the properties object for the service

- Set the customizable SAX Parser Service Properties.

This method attempts to instantiate a validating parser and a namespaceaware parser to determine if the parser can support those features. The appropriate properties are then set in the specified properties object.

This method can be overridden to add additional SAX2 features and properties. If you want to be able to filter searches of the OSGi service registry, this method must put a key, value pair into the properties object for each feature or property. For example, `properties.put("http://www.acme.com/features/foo", Boolean.TRUE);`

**702.9.1.11      public void start( BundleContext context ) throws Exception**

*context* The execution context of the bundle being started.

- Called when this bundle is started so the Framework can perform the bundle-specific activities necessary to start this bundle. This method can be used to register services or to allocate any resources that this bundle needs.

This method must complete and return to its caller in a timely manner.

This method attempts to register a SAX and DOM parser with the Framework's service registry.

*Throws* Exception – If this method throws an exception, this bundle is marked as stopped and the Framework will remove this bundle's listeners, unregister

all services registered by this bundle, and release all services used by this bundle.

*See Also* `Bundle.start`

#### **702.9.1.12      `public void stop( BundleContext context )` throws Exception**

*context* The execution context of the bundle being stopped.

- This method has nothing to do as all active service registrations will automatically get unregistered when the bundle stops.

*Throws* Exception – If this method throws an exception, the bundle is still marked as stopped, and the Framework will remove the bundle's listeners, unregister all services registered by the bundle, and release all services used by the bundle.

*See Also* `Bundle.stop`

#### **702.9.1.13      `public void ungetService( Bundle bundle, ServiceRegistration registration, Object service )`**

*bundle* The bundle releasing the service.

*registration* The ServiceRegistration object for the service.

*service* The XML Parser Factory object returned by a previous call to the `getService` method.

- Releases a XML Parser Factory object.

## **702.10      References**

- [55] *XML*  
<http://www.w3.org/XML>
- [56] *SAX*  
<http://www.saxproject.org/>
- [57] *DOM Java Language Binding*  
<http://www.w3.org/TR/REC-DOM-Level-1/java-language-binding.html>
- [58] *JAXP*  
<http://java.sun.com/xml/jaxp>
- [59] *JAR File specification, services directory*  
<http://java.sun.com/j2se/1.4/docs/guide/jar/jar.html>
- [60] *Xerces 2 Java Parser*  
<http://xml.apache.org/xerces2-j>

# 703 Position Specification

## Version 1.0

### 703.1 Introduction

The Position class is a utility providing bundle developers with a consistent way of handling geographic positions in OSGi applications. The Position class is intended to be used with the Wire Admin service but has wider applicability.

The Position class is designed to be compatible with the Global Positioning System (GPS). This specification will not define or explain the complexities of positioning information. It is assumed that the reader has the appropriate background to understand this information.

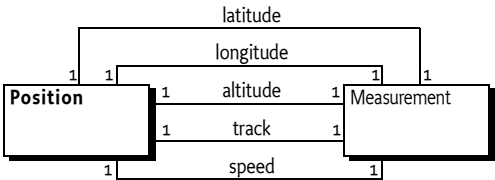
#### 703.1.1 Essentials

- *Position* – Provide an information object that has well defined semantics for a position.
- *WGS-84* – Use the World Geodetic System 84 as the datum.
- *Speed* – Provide speed and track information.
- *Errors* – Position information always has certain errors or cannot be measured at all. This information must be available to the users of the information.
- *Units* – Use SI units for all measurements.
- *Wire Admin* – This specification must work within the Wire Admin service.

#### 703.1.2 Entities

- *Position* – An object containing the different aspects of a position.
- *Measurement* – Contains a typed measurement made at a certain time and with a specified error.

Figure 53 Class Diagram, *org.osgi.util.position*



## 703.2 Positioning

The Position class is used to give information about the position and movement of a vehicle with a specified amount of uncertainty. The position is based on WGS-84.

The Position class offers the following information:

- `getLatitude()` – The WGS-84 latitude of the current position. The unit of a latitude must be rad (radians).
- `getLongitude()` – The WGS-84 longitude of the current position. The unit of a longitude must be rad (radians).
- `getAltitude()` – Altitude is expressed as height in meters above the WGS-84 ellipsoid. This value can differ from the actual height above mean sea level depending on the place on earth where the measurement is taken place. This value is not corrected for the geoid.
- `getTrack()` – The true north course of the vehicle in radians.
- `getSpeed()` – The ground speed. This speed must not include vertical speed.

## 703.3 Units

Longitude and latitude are represented in radians, not degrees. This is consistent with the use of the Measurement object. Radians can be converted to degrees with the following formula, when lonlat is the longitude or latitude:

$$\text{degrees} = (\text{lonlat} / \pi) * 180$$

Calculation errors are significantly reduced when all calculations are done with a single unit system. This approach increases the complexity of presentation, but presentations are usually localized and require conversion anyway. Also, the radians are the units in the SI system and the `java.lang.Math` class uses only radians for angles.

## 703.4 Optimizations

A Position object must be immutable. It must remain its original values after it is created.

The Position class is not final. This approach implies that developers are allowed to sub-class it and provide optimized implementations. For example, it is possible that the Measurement objects are only constructed when actually requested.

## 703.5 Errors

Positioning information is never exact. Even large errors can exist in certain conditions. For this reason, the Position class returns all its measurements as Measurement objects. The Measurement class maintains an error value for each measurement.

In certain cases it is not possible to supply a value; in those cases, the method should return a NaN as specified in the Measurement class.

## 703.6 Using Position With Wire Admin

The primary reason the Position is specified, is to use it with the *Wire Admin Service Specification* on page 151. A bundle that needs position information should register a Consumer service and the configuration should connect this service to an appropriate Producer service.

## 703.7 Related Standards

### 703.7.1 JSR 179

In JCP, started [63] *Location API for J2ME*. This API is targeted at embedded systems and is likely to not contain some of the features found in this API. This API is targeted to be reviewed at Q4 of 2002. This API should be considered in a following release.

## 703.8 Security

The security aspects of the Position class are delegated to the security aspects of the Wire Admin service. The Position object only carries the information. The Wire Admin service will define what Consumer services will receive position information from what Producer services. It is therefore up to the administrator of the Wire Admin service to assure that only trusted bundles receive this information, or can supply it.

## 703.9 org.osgi.util.position

The OSGi Position Package. Specification Version 1.0.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

```
Import-Package: org.osgi.util.position; version=1.0
```

### 703.9.1 public class Position

Position represents a geographic location, based on the WGS84 System (World Geodetic System 1984).

The org.osgi.util.measurement.Measurement class is used to represent the values that make up a position.

A given position object may lack any of it's components, i.e. the altitude may not be known. Such missing values will be represented by null.

Position does not override the implementation of either equals() or hashCode() because it is not clear how missing values should be handled. It is up to the user of a position to determine how best to compare two position objects. A Position object is immutable.

- 703.9.1.1**      **public Position( Measurement lat, Measurement lon, Measurement alt, Measurement speed, Measurement track )**
- lat*   a Measurement object specifying the latitude in radians, or null
- lon*   a Measurement object specifying the longitude in radians, or null
- alt*   a Measurement object specifying the altitude in meters, or null
- speed*   a Measurement object specifying the speed in meters per second, or null
- track*   a Measurement object specifying the track in radians, or null
- Constructs a Position object with the given values.
- 703.9.1.2**      **public Measurement getAltitude( )**
- Returns the altitude of this position in meters.
- Returns*   a Measurement object in Unit.m representing the altitude in meters above the ellipsoid null if the altitude is not known.
- 703.9.1.3**      **public Measurement getLatitude( )**
- Returns the latitude of this position in radians.
- Returns*   a Measurement object in Unit.rad representing the latitude, or null if the latitude is not known..
- 703.9.1.4**      **public Measurement getLongitude( )**
- Returns the longitude of this position in radians.
- Returns*   a Measurement object in Unit.rad representing the longitude, or null if the longitude is not known.
- 703.9.1.5**      **public Measurement getSpeed( )**
- Returns the ground speed of this position in meters per second.
- Returns*   a Measurement object in Unit.m\_s representing the speed, or null if the speed is not known..
- 703.9.1.6**      **public Measurement getTrack( )**
- Returns the track of this position in radians as a compass heading. The track is the extrapolation of previous previously measured positions to a future position.
- Returns*   a Measurement object in Unit.rad representing the track, or null if the track is not known..

## 703.10      References

- [61]   *World Geodetic System 84 (WGS-84)*  
<http://www.wgs84.com>
- [62]   *Location Interoperability Forum*  
<http://www.locationforum.org/>
- [63]   *Location API for J2ME*  
<http://www.jcp.org/jsr/detail/179.jsp>



# 704 Measurement and State Specification

*Version 1.0*

## 704.1 Introduction

The Measurement class is a utility that provides a consistent way of handling a diverse range of measurements for bundle developers. Its purpose is to simplify the correct handling of measurements in OSGi Service Platforms.

OSGi bundle developers from all over the world have different preferences for measurement units, such as feet versus meters. In an OSGi environment, bundles developed in different parts of the world can and will exchange measurements when collaborating.

Distributing a measurement such as a simple floating point number requires the correct and equal understanding of the measurement's semantic by both the sender and the receiver. Numerous accidents have occurred due to misunderstandings between the sender and receiver because there are so many different ways to represent the same value. For example, on September 23, 1999, the Mars Polar Lander was lost because calculations used to program the craft's trajectory were input with English units while the operation documents specified metric units. See [68] *Mars Polar Lander failure* for more information.

This Measurement and State Specification defines the norm that should be used by all applications that execute in an OSGi Service Platform. This specification also provides utility classes.

### 704.1.1 Measurement Essentials

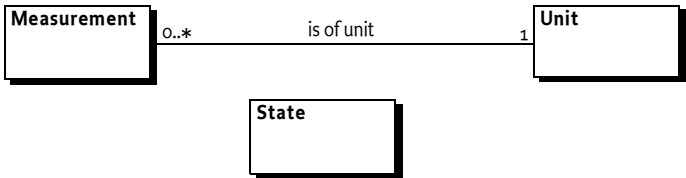
- *Numerical error* – All floating point measurements should be able to have a numerical error.
- *Numerical error calculations simplification* – Support should be provided to simplify measurements calculations.
- *Unit conflict resolution* – It must not be possible to perform addition or subtraction with different units when they are not compatible. For example, it must not be possible to add meters to amperes or watts to pascals.
- *Unit coercion* – Multiplication and division operations involving more than one type of measurement must result in a different unit. For example, if meters are divided by seconds, the result must be a new unit that represents m/s.
- *Time-stamp* – Measurements should contain a time-stamp so that bundles can determine the age of a particular measurement.

- *Support for floating and discrete values* – Both floating point values (64 bit Java double floats) and discrete measurements (32 bit Java int) should be supported.
- *Consistency* – The method of error calculation and handling of unit types should be consistent.
- *Presentation* – The format of measurements and specified units should be easy to read and understand.

704.1.2 Measurement Entities

- *Measurement object* – A Measurement object contains a double value, a double error, and a long time-stamp. It is associated with a Unit object that represents its *type*.
- *State object* – A State object contains a discrete measurement (int) with a time-stamp and a name.
- *Unit object* – A Unit object represents a unit such as meter, second, mol, or Pascal. A number of Unit objects are predefined and have common names. Other Unit objects are created as needed from the 7 basic *Système International d’Unité* (SI) units. Different units are *not* used when a conversion is sufficient. For example, the unit of a Measurement object for length is *always* meters. If the length is needed in feet, then the number of feet is calculated by multiplying the value of the Measurement object in meters with the necessary conversion factor.
- *Error* – When a measurement is taken, it is *never* accurate. This specification defines the error as the value that is added and subtracted to the value to produce an interval, where the probability is 95% that the actual value falls within this interval.
- *Unit* – A unit is the *type* of a measurement: meter, feet, liter, gallon etc.
- *Base Unit* – One of the 7 base units defined in the SI.
- *Derived SI unit* – A unit is a derived SI unit when it is a combination of exponentiated base units. For example, a volt (V) is a derived unit because it can be expressed as  $(m^2 \times kg) / (s^3 \times A)$ , where m, kg, s and A are all base units.
- *Quantitative derivation* – A unit is quantitatively derived when it is converted to one of the base units or derived units using a conversion formula. For example, kilometers (km) can be converted to meters (m), gallons can be converted to liters, or horsepower can be converted to watts.

Figure 54 Class Diagram, org.osgi.util.measurement



## 704.2 Measurement Object

A Measurement object contains a value, an error, and a time-stamp. It is linked to a Unit object that describes the measurement unit in an SI Base Unit or Derived SI Unit.

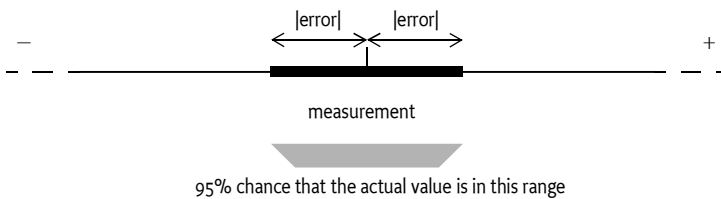
### 704.2.1 Value

The value of the Measurement object is the measured value. It is set in a constructor. The type of the value is double.

### 704.2.2 Error

The Measurement object can contain a numerical error. This error specifies an interval by adding and subtracting the error value from the measured value. The type of the error is double. A valid error value indicates that the actual measured value has a 95% chance of falling within this interval (see Figure 2). If the error is not known it should be represented as a Double.NaN.

Figure 55 The Error Interval



### 704.2.3 Time-stamp

When a Measurement object is created, the time-stamp can be set. A time-stamp is a long value representing the number of milliseconds since the epoch midnight of January 1, 1970, UTC (this is the value from System.currentTimeMillis() method).

By default, a time-stamp is not set because the call to System.currentTimeMillis() incurs overhead. If the time-stamp is not set when the Measurement object is created, then its default value is zero. If the time-stamp is set, the creator of the Measurement object must give the time as an argument to the constructor. For example:

```
Measurement m = new Measurement(
 v, e, null, System.currentTimeMillis());
```

# 704.3 Error Calculations

Once a measurement is taken, it often is used in calculations. The error value assigned to the result of a calculation depends largely on the error values of the operands. Therefore, the Measurement class offers addition, subtraction, multiplication, and division functions for measurements and constants. These functions take the error into account when performing the specific operation.

The Measurement class uses absolute errors and has methods to calculate a new absolute error when multiplication, division, addition, or subtraction is performed. Error calculations must therefore adhere to the rules listed in Table 25. In this table,  $\Delta a$  is the absolute positive error in a value  $a$  and  $\Delta b$  is the absolute positive error in a value  $b$ .  $c$  is a constant floating point value without an error.

Table 25 Error Calculation Rules

| Calculation  | Function                      | Error                                                     |
|--------------|-------------------------------|-----------------------------------------------------------|
| $a \times b$ | <code>mul(Measurement)</code> | $  \Delta a \times b   +   a \times \Delta b  $           |
| $a / b$      | <code>div(Measurement)</code> | $(   \Delta a \times b   +   a \times \Delta b   ) / b^2$ |
| $a + b$      | <code>add(Measurement)</code> | $\Delta a + \Delta b$                                     |
| $a - b$      | <code>sub(Measurement)</code> | $\Delta a + \Delta b$                                     |
| $a \times c$ | <code>mul(double)</code>      | $  \Delta a \times c  $                                   |
| $a / c$      | <code>div(double)</code>      | $  \Delta a / c  $                                        |
| $a + c$      | <code>add(double)</code>      | $\Delta a$                                                |
| $a - c$      | <code>sub(double)</code>      | $\Delta a$                                                |

# 704.4 Constructing and Comparing Measurements

Measurement objects have a value and an error range, making comparing and constructing these objects more complicated than normal scalars.

## 704.4.1 Constructors

The Measurements object has the following constructors that the value, error, unit and timestamp:

- `Measurement(double,double,Unit,long)`
- `Measurement(double,double,Unit)`
- `Measurement(double,Unit)`
- `Measurement(double)`

Additionally, there is a String constructor so that the a Measurement object can be created from a String, this is a necessity if Measurement objects are to be used with filters.

The syntax of the string given to the constructor is:

```
Measurement ::= double ':' unit [':' error]
```

```

double ::= <Java Double String constructor>
unit ::= ('1' | expr) ['/' expr]
expr ::= (<Unit name> [exponent]) *
exponent ::= [1-5]

```

For example:

```

10.49: m/s
15: Ohm
9.8: m/s2: 0.1
20: sA2/m2kg

```

Units are case sensitive, it is therefore important to specify the right case.

## 704.4.2 Identity and Equality

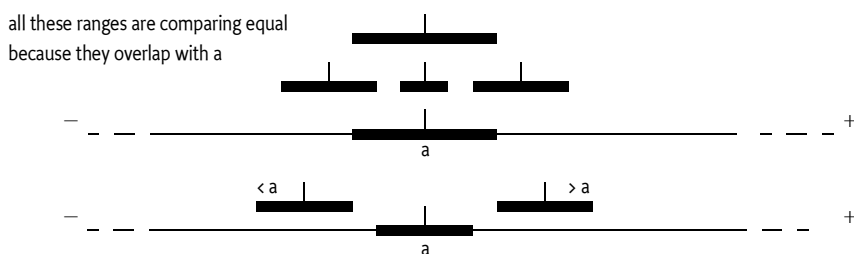
Both `equals(Object)` and `hashCode()` methods are overridden to provide value-based equality. Two Measurement objects are equal when the unit, error, and value are the same. The time-stamp is not relevant for equality or the hash code.

## 704.4.3 Comparing Measurement Objects

The Measurement class implements the `java.lang.Comparable` interface and thus implements the `compareTo(Object)` method. Comparing two Measurement objects is not straightforward, however, due to the associated error. The error effectively creates a range, so comparing two Measurement objects is actually comparing intervals.

Two Measurement objects are considered to be equal when their intervals overlap. In all other cases, the value is used in the comparison.

Figure 56 Comparing Measurement Objects



This comparison implies that the `equals(Object)` method may return false while the `compareTo(Object)` method returns 0 for the same Measurement object.

# 704.5 Unit Object

Each Measurement object is related to a Unit object. The Unit object defines the unit of the measurement value and error. For example, the Unit object might define the unit of the measurement value and the error as meters (m). For convenience, the Unit class defines a number of standard units as constants. Measurement objects are given a specific Unit with the constructor. The following example shows how a measurement can be associated with meters (m):

```
Measurement length = new Measurement(v, 0.01, Unit.m);
```

Units are based on the *Système International d'Unité* (SI), developed after the French Revolution. The SI consists of 7 different units that can be combined in many ways to form a large series of derived units. The basic 7 units are listed in Table 26. For more information, see [65] *General SI index*.

Table 26 Basic SI units.

| Description               | Unit name | Symbol |
|---------------------------|-----------|--------|
| length                    | meter     | m      |
| mass                      | kilogram  | kg     |
| time                      | second    | s      |
| electric current          | ampere    | A      |
| thermodynamic temperature | kelvin    | K      |
| amount of substance       | mole      | mol    |
| luminous intensity        | candela   | cd     |

Additional units are derived in the following ways:

Derived units can be a combination of exponentiated base units. For example, Hz (Hertz) is the unit for frequencies and is actually derived from the calculation of 1/s. A more complicated derived unit is volt (V). A volt is actually:

$$( m^2 \times kg ) / ( s^3 \times A )$$

The SI defines various derived units with their own name, for example pascal (Pa), watt (W), volt (V), and many more.

The Measurement class must maintain its unit by keeping track of the exponents of the 7 basic SI units.

If different units are used in addition or subtraction of Measurement objects, an ArithmeticException must be thrown.

```
Measurement length = new Measurement(v1, 0.01, Unit.m);
Measurement duration = new Measurement(v2, 0, Unit.s);
try {
 Measurement r = length.add(duration);
}
catch(ArithmeticException e) {
 // This must be thrown
}
```

When two Measurement objects are multiplied, the Unit object of the result contains the sum of the exponents. When two Measurement objects are divided, the exponents of the Unit object of the result are calculated by subtraction of the exponents.

The Measurement class must support exponents of -64 to +63. Overflow must not be reported but must result in an invalid Unit object. All calculations with an invalid Unit object should result in an invalid Unit object. Typical computations generate exponents for units between +/- 4.

### 704.5.1

## Quantitive Differences

The base and derived units can be converted to other units that are of the same *quality*, but require a conversion because their scales and offsets may differ. For example, degrees Fahrenheit, kelvin, and Celsius are all temperatures and, therefore, only differ in their quantity. Kelvin and Celsius are the same scale and differ only in their starting points. Fahrenheit differs from kelvin in that both scale and starting point differ.

Using different Unit objects for the units that differ only in quantity can easily introduce serious software bugs. Therefore, the Unit class utilizes the SI units. Any exchange of measurements should be done using SI units to prevent these errors. When a measurement needs to be displayed, the presentation logic should perform the necessary conversions to present it in a localized form. For example, when speed is presented in a car purchased in the United States, it should be presented as miles instead of meters.

### 704.5.2

## Why Use SI Units?

The adoption of the SI in the United States and the United Kingdom has met with resistance. This issue raises the question why the SI system has to be the preferred measurement system in the OSGi Specifications.

The SI system is utilized because it is the only measurement *system* that has a consistent set of base units. The base units can be combined to create a large number of derived units without requiring a large number of complicated conversion formulas. For example, a watt is simply a combination of meters, kilograms, and seconds ( $\text{m}^2 \times \text{kg} / \text{s}^3$ ). In contrast, horsepower is not easily related to inches, feet, fathoms, yards, furlongs, ounces, pounds, stones, or miles. This difficulty is the reason that science has utilized the SI for a long time. It is also the reason that the SI has been chosen as the system used for the Measurement class.

The purpose of the Measurement class is internal, however, and should not restrict the usability of the OSGi environment. Users should be able to use the local measurement units when data is input or displayed. This choice is the responsibility of the application developer.

## 704.6 State Object

The State object is used to represent discrete states. It contains a time-stamp but does not contain an error or Unit object. The Measurement object is not suitable to maintain discrete states. For example, a car door can be LOCKED, UNLOCKED, or CHILDLCKED. Measuring and operating with these values does not require error calculations, nor does it require SI units. Therefore, the State object is a simple, named object that holds an integer value.

## 704.7 Related Standards

### 704.7.1 GNU Math Library in Kawa

The open source project Kawa, a scheme-based Java environment, has included a gnu.math library that contains unit handling similar to this specification. It can be found at [67] *A Math Library containing unit handling in Kawa*.

The library seems considerably more complex without offering much more functionality than this specification. It also does not strictly separate basic SI units such as meter from quantitatively derived units such as pica.

## 704.8 Security Considerations

The Measurement, Unit, and State classes have been made immutable. Instances of these classes can be freely handed out to other bundles because they cannot be extended, nor can the value, error, or time-stamp be altered after the object is created.

## 704.9 org.osgi.util.measurement

The OSGi Measurement Package. Specification Version 1.0.

Bundles wishing to use this package must list the package in the Import-Package header of the bundle's manifest. For example:

```
Import-Package: org.osgi.util.measurement; version=1.0
```

### 704.9.1 Summary

- Measurement - Represents a value with an error, a unit and a time-stamp. [p.366]
- State - Groups a state name, value and timestamp. [p.371]
- Unit - A unit system for measurements. [p.372]

### 704.9.2 **public class Measurement implements Comparable**

Represents a value with an error, a unit and a time-stamp.



A Measurement object is used for maintaining the tuple of value, error, unit and time-stamp. The value and error are represented as doubles and the time is measured in milliseconds since midnight, January 1, 1970 UTC.

Mathematic methods are provided that correctly calculate taking the error into account. A runtime error will occur when two measurements are used in an incompatible way. E.g., when a speed (m/s) is added to a distance (m). The measurement class will correctly track changes in unit during multiplication and division, always coercing the result to the most simple form. See Unit[p.372] for more information on the supported units.

Errors in the measurement class are absolute errors. Measurement errors should use the P95 rule. Actual values must fall in the range value +/- error 95% or more of the time.

A Measurement object is immutable in order to be easily shared.

Note: This class has a natural ordering that is inconsistent with equals. See compareTo[p.368].

#### **704.9.2.1      public Measurement( double value, double error, Unit unit, long time )**

*value* The value of the Measurement.

*error* The error of the Measurement.

*unit* The Unit object in which the value is measured. If this argument is null, then the unit will be set to Unit.unity[p.374].

*time* The time measured in milliseconds since midnight, January 1, 1970 UTC.

- Create a new Measurement object.

#### **704.9.2.2      public Measurement( double value, double error, Unit unit )**

*value* The value of the Measurement.

*error* The error of the Measurement.

*unit* The Unit object in which the value is measured. If this argument is null, then the unit will be set to Unit.unity[p.374].

- Create a new Measurement object with a time of zero.

#### **704.9.2.3      public Measurement( double value, Unit unit )**

*value* The value of the Measurement.

*unit* The Unit in which the value is measured. If this argument is null, then the unit will be set to Unit.unity[p.374].

- Create a new Measurement object with an error of 0.0 and a time of zero.

#### **704.9.2.4      public Measurement( double value )**

*value* The value of the Measurement.

- Create a new Measurement object with an error of 0.0, a unit of Unit.unity[p.374] and a time of zero.

#### **704.9.2.5      public Measurement add( Measurement m )**

*m* The Measurement object that will be added with this object.

- Returns a new Measurement object that is the sum of this object added to the specified object. The error and unit of the new object are computed. The time of the new object is set to the time of this object.

*Returns* A new Measurement object that is the sum of this and m.

*Throws* ArithmeticException – If the Unit objects of this object and the specified object cannot be added.

*See Also* Unit[p.372]

#### **704.9.2.6      public Measurement add( double d, Unit u )**

*d* The value that will be added with this object.

*u* The Unit object of the specified value.

- Returns a new Measurement object that is the sum of this object added to the specified value.

*Returns* A new Measurement object that is the sum of this object added to the specified value. The unit of the new object is computed. The error and time of the new object is set to the error and time of this object.

*Throws* ArithmeticException – If the Unit objects of this object and the specified value cannot be added.

*See Also* Unit[p.372]

#### **704.9.2.7      public Measurement add( double d )**

*d* The value that will be added with this object.

- Returns a new Measurement object that is the sum of this object added to the specified value.

*Returns* A new Measurement object that is the sum of this object added to the specified value. The error, unit, and time of the new object is set to the error, Unit and time of this object.

#### **704.9.2.8      public int compareTo( Object obj )**

*obj* The object to be compared.

- Compares this object with the specified object for order. Returns a negative integer, zero, or a positive integer if this object is less than, equal to, or greater than the specified object.

Note: This class has a natural ordering that is inconsistent with equals. For this method, another Measurement object is considered equal if there is some x such that

```
getValue() - getError() <= x <= getValue() + getError()
```

for both Measurement objects being compared.

*Returns* A negative integer, zero, or a positive integer if this object is less than, equal to, or greater than the specified object.

*Throws* ClassCastException – If the specified object is not of type Measurement.

ArithmeticException – If the unit of the specified Measurement object is not equal to the Unit object of this object.

**704.9.2.9      public Measurement div( Measurement m )**

*m* The Measurement object that will be the divisor of this object.

- Returns a new Measurement object that is the quotient of this object divided by the specified object.

*Returns* A new Measurement object that is the quotient of this object divided by the specified object. The error and unit of the new object are computed. The time of the new object is set to the time of this object.

*Throws* ArithmeticException – If the Unit objects of this object and the specified object cannot be divided.

*See Also* Unit[p.372]

**704.9.2.10      public Measurement div( double d, Unit u )**

*d* The value that will be the divisor of this object.

*u* The Unit object of the specified value.

- Returns a new Measurement object that is the quotient of this object divided by the specified value.

*Returns* A new Measurement that is the quotient of this object divided by the specified value. The error and unit of the new object are computed. The time of the new object is set to the time of this object.

*Throws* ArithmeticException – If the Unit objects of this object and the specified object cannot be divided.

*See Also* Unit[p.372]

**704.9.2.11      public Measurement div( double d )**

*d* The value that will be the divisor of this object.

- Returns a new Measurement object that is the quotient of this object divided by the specified value.

*Returns* A new Measurement object that is the quotient of this object divided by the specified value. The error of the new object is computed. The unit and time of the new object is set to the Unit and time of this object.

**704.9.2.12      public boolean equals( Object obj )**

*obj* The object to compare with this object.

- Returns whether the specified object is equal to this object. Two Measurement objects are equal if they have same value, error and Unit.

Note: This class has a natural ordering that is inconsistent with equals. See compareTo[p.368].

*Returns* true if this object is equal to the specified object; false otherwise.

**704.9.2.13      public final double getError( )**

- Returns the error of this Measurement object. The error is always a positive value.

*Returns* The error of this Measurement as a double.

**704.9.2.14      public final long getTime( )**

- ❑ Returns the time at which this Measurement object was taken. The time is measured in milliseconds since midnight, January 1, 1970 UTC, or zero when not defined.

*Returns* The time at which this Measurement object was taken or zero.

**704.9.2.15      public final Unit getUnit( )**

- ❑ Returns the Unit object of this Measurement object.

*Returns* The Unit object of this Measurement object.

*See Also* Unit[p.372]

**704.9.2.16      public final double getValue( )**

- ❑ Returns the value of this Measurement object.

*Returns* The value of this Measurement object as a double.

**704.9.2.17      public int hashCode( )**

- ❑ Returns a hash code value for this object.

*Returns* A hash code value for this object.

**704.9.2.18      public Measurement mul( Measurement m )**

*m* The Measurement object that will be multiplied with this object.

- ❑ Returns a new Measurement object that is the product of this object multiplied by the specified object.

*Returns* A new Measurement that is the product of this object multiplied by the specified object. The error and unit of the new object are computed. The time of the new object is set to the time of this object.

*Throws* ArithmeticException – If the Unit objects of this object and the specified object cannot be multiplied.

*See Also* Unit[p.372]

**704.9.2.19      public Measurement mul( double d, Unit u )**

*d* The value that will be multiplied with this object.

*u* The Unit of the specified value.

- ❑ Returns a new Measurement object that is the product of this object multiplied by the specified value.

*Returns* A new Measurement object that is the product of this object multiplied by the specified value. The error and unit of the new object are computed. The time of the new object is set to the time of this object.

*Throws* ArithmeticException – If the units of this object and the specified value cannot be multiplied.

*See Also* Unit[p.372]

**704.9.2.20      public Measurement mul( double d )**

*d* The value that will be multiplied with this object.

- Returns a new Measurement object that is the product of this object multiplied by the specified value.

*Returns* A new Measurement object that is the product of this object multiplied by the specified value. The error of the new object is computed. The unit and time of the new object is set to the unit and time of this object.

#### **704.9.2.21      public Measurement sub( Measurement m )**

*m* The Measurement object that will be subtracted from this object.

- Returns a new Measurement object that is the subtraction of the specified object from this object.

*Returns* A new Measurement object that is the subtraction of the specified object from this object. The error and unit of the new object are computed. The time of the new object is set to the time of this object.

*Throws* ArithmeticException – If the Unit objects of this object and the specified object cannot be subtracted.

*See Also* Unit[p.372]

#### **704.9.2.22      public Measurement sub( double d, Unit u )**

*d* The value that will be subtracted from this object.

*u* The Unit object of the specified value.

- Returns a new Measurement object that is the subtraction of the specified value from this object.

*Returns* A new Measurement object that is the subtraction of the specified value from this object. The unit of the new object is computed. The error and time of the new object is set to the error and time of this object.

*Throws* ArithmeticException – If the Unit objects of this object and the specified object cannot be subtracted.

*See Also* Unit[p.372]

#### **704.9.2.23      public Measurement sub( double d )**

*d* The value that will be subtracted from this object.

- Returns a new Measurement object that is the subtraction of the specified value from this object.

*Returns* A new Measurement object that is the subtraction of the specified value from this object. The error, unit and time of the new object is set to the error, Unit object and time of this object.

#### **704.9.2.24      public String toString( )**

- Returns a String object representing this Measurement object.

*Returns* a String object representing this Measurement object.

### **704.9.3      public class State**

Groups a state name, value and timestamp.

The state itself is represented as an integer and the time is measured in milliseconds since midnight, January 1, 1970 UTC.

A State object is immutable so that it may be easily shared.

**704.9.3.1      public State( int value, String name, long time )**

*value*   The value of the state.

*name*   The name of the state.

*time*   The time measured in milliseconds since midnight, January 1, 1970 UTC.

- Create a new State object.

**704.9.3.2      public State( int value, String name )**

*value*   The value of the state.

*name*   The name of the state.

- Create a new State object with a time of 0.

**704.9.3.3      public boolean equals( Object obj )**

*obj*   The object to compare with this object.

- Return whether the specified object is equal to this object. Two State objects are equal if they have same value and name.

*Returns*   true if this object is equal to the specified object; false otherwise.

**704.9.3.4      public final String getName( )**

- Returns the name of this State.

*Returns*   The name of this State object.

**704.9.3.5      public final long getTime( )**

- Returns the time with which this State was created.

*Returns*   The time with which this State was created. The time is measured in milliseconds since midnight, January 1, 1970 UTC.

**704.9.3.6      public final int getValue( )**

- Returns the value of this State.

*Returns*   The value of this State object.

**704.9.3.7      public int hashCode( )**

- Returns a hash code value for this object.

*Returns*   A hash code value for this object.

**704.9.3.8      public String toString( )**

- Returns a String object representing this object.

*Returns*   a String object representing this object.

**704.9.4      public class Unit**

A unit system for measurements. This class contains definitions of the most common SI units.

This class only support exponents for the base SI units in the range -64 to +63. Any operation which produces an exponent outside of this range will result in a Unit object with undefined exponents.

**704.9.4.1      public static final Unit A**

The electric current unit ampere (A)

**704.9.4.2      public static final Unit C**

The electric charge unit coulomb (C).  
coulomb is expressed in SI units as s · A

**704.9.4.3      public static final Unit cd**

The luminous intensity unit candela (cd)

**704.9.4.4      public static final Unit F**

The capacitance unit farad (F).  
farad is equal to C/V or is expressed in SI units as s<sup>4</sup> · A<sup>2</sup> / m<sup>2</sup> · kg

**704.9.4.5      public static final Unit Gy**

The absorbed dose unit gray (Gy).  
Gy is equal to J/kg or is expressed in SI units as m<sup>2</sup> / s<sup>2</sup>

**704.9.4.6      public static final Unit Hz**

The frequency unit hertz (Hz).  
hertz is expressed in SI units as 1/s

**704.9.4.7      public static final Unit J**

The energy unit joule (J).  
joule is equal to N · m or is expressed in SI units as m<sup>2</sup> · kg/s<sup>2</sup>

**704.9.4.8      public static final Unit K**

The temperature unit kelvin (K)

**704.9.4.9      public static final Unit kat**

The catalytic activity unit katal (kat).  
katal is expressed in SI units as mol/s

**704.9.4.10     public static final Unit kg**

The mass unit kilogram (kg)

**704.9.4.11     public static final Unit lx**

The illuminance unit lux (lx).  
lux is expressed in SI units as cd/m<sup>2</sup>

|                   |                                                                                                                                                                                                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>704.9.4.12</b> | <b>public static final Unit m</b><br>The length unit meter (m)                                                                                                                                 |
| <b>704.9.4.13</b> | <b>public static final Unit m2</b><br>The area unit square meter(m <sup>2</sup> )                                                                                                              |
| <b>704.9.4.14</b> | <b>public static final Unit m3</b><br>The volume unit cubic meter (m <sup>3</sup> )                                                                                                            |
| <b>704.9.4.15</b> | <b>public static final Unit m_s</b><br>The speed unit meter per second (m/s)                                                                                                                   |
| <b>704.9.4.16</b> | <b>public static final Unit m_s2</b><br>The acceleration unit meter per second squared (m/s <sup>2</sup> )                                                                                     |
| <b>704.9.4.17</b> | <b>public static final Unit mol</b><br>The amount of substance unit mole (mol)                                                                                                                 |
| <b>704.9.4.18</b> | <b>public static final Unit N</b><br>The force unit newton (N).<br>N is expressed in SI units as m· kg/s <sup>2</sup>                                                                          |
| <b>704.9.4.19</b> | <b>public static final Unit Ohm</b><br>The electric resistance unit ohm.<br>ohm is equal to V/A or is expressed in SI units as m <sup>2</sup> · kg/s <sup>3</sup> · A <sup>2</sup>             |
| <b>704.9.4.20</b> | <b>public static final Unit Pa</b><br>The pressure unit pascal (Pa).<br>Pa is equal to N/m <sup>2</sup> or is expressed in SI units as kg/m · s <sup>2</sup>                                   |
| <b>704.9.4.21</b> | <b>public static final Unit rad</b><br>The angle unit radians (rad)                                                                                                                            |
| <b>704.9.4.22</b> | <b>public static final Unit S</b><br>The electric conductance unit siemens (S).<br>siemens is equal to A/V or is expressed in SI units as s <sup>3</sup> · A <sup>2</sup> /m <sup>2</sup> · kg |
| <b>704.9.4.23</b> | <b>public static final Unit s</b><br>The time unit second (s)                                                                                                                                  |
| <b>704.9.4.24</b> | <b>public static final Unit T</b><br>The magnetic flux density unit tesla (T).<br>tesla is equal to Wb/m <sup>2</sup> or is expressed in SI units as kg/s <sup>2</sup> · A                     |



|            |                                                                                                                                                                                                                                                                                                                                                                       |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 704.9.4.25 | <b>public static final Unit unity</b><br>No Unit (Unity)                                                                                                                                                                                                                                                                                                              |
| 704.9.4.26 | <b>public static final Unit V</b><br>The electric potential difference unit volt (V).<br>volt is equal to W/A or is expressed in SI units as $m^2 \cdot kg/s^3 \cdot A$                                                                                                                                                                                               |
| 704.9.4.27 | <b>public static final Unit W</b><br>The power unit watt (W).<br>watt is equal to J/s or is expressed in SI units as $m^2 \cdot kg/s^3$                                                                                                                                                                                                                               |
| 704.9.4.28 | <b>public static final Unit Wb</b><br>The magnetic flux unit weber (Wb).<br>weber is equal to $V \cdot s$ or is expressed in SI units as $m^2 \cdot kg/s^2 \cdot A$                                                                                                                                                                                                   |
| 704.9.4.29 | <b>public boolean equals( Object obj )</b><br><i>obj</i> the Unit object that should be checked for equality<br><input type="checkbox"/> Checks whether this Unit object is equal to the specified Unit object. The Unit objects are considered equal if their exponents are equal.<br><i>Returns</i> true if the specified Unit object is equal to this Unit object. |
| 704.9.4.30 | <b>public int hashCode( )</b><br><input type="checkbox"/> Returns the hash code for this object.<br><i>Returns</i> This object's hash code.                                                                                                                                                                                                                           |
| 704.9.4.31 | <b>public String toString( )</b><br><input type="checkbox"/> Returns a String object representing the Unit<br><i>Returns</i> A String object representing the Unit                                                                                                                                                                                                    |

## 704.10 References

[64] *SI Units information*  
<http://physics.nist.gov/cuu/Units>

[65] *General SI index*  
[http://directory.google.com/Top/Science/Reference/Units\\_of\\_Measurement](http://directory.google.com/Top/Science/Reference/Units_of_Measurement)

[66] *JSR 108 Units Specification*  
<http://www.jcp.org/jsr/detail/108.jsp>

[67] *A Math Library containing unit handling in Kawa*  
<http://www.gnu.org/software/kawa>

[68] *Mars Polar Lander failure*  
<http://mars.jpl.nasa.gov/msp98/news/mco990930.html>



# 999 Execution Environment Specification

## Version 1.1

### 999.1 Introduction

This specification defines two different execution environments for OSGi Server Platform Servers. One is based on a minimal environment that supports OSGi Framework and basic services implementations. The other is derived from [74] *Foundation Profile*. Care has been taken to make the minimum requirements a proper subset of Foundation Profile.

This chapter contains a detailed listing of the Execution Environments. This list is the actual specification and is normative. However, this list is not suited for tools. Therefore, the OSGi web site provides the JAR files that contain all the signatures of the Execution Environments on the OSGi web site, see [70] *Downloadable Execution Environments*.

Please note that the OSGi Minimum Execution Requirements do not constitute a specification for a Java technology profile or platform under the Java Community Process, but rather are a list of dependencies on certain elements of the presumed underlying Java profile(s) or platform(s).

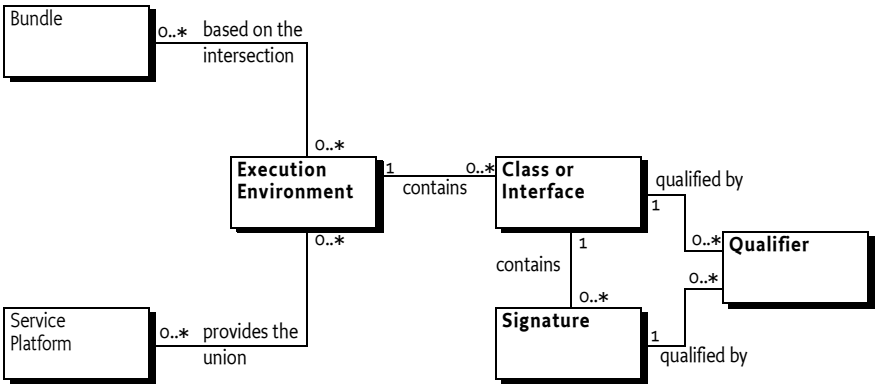
#### 999.1.1 Essentials

- *Bundle Environment* – A well defined format with handling rules for defining the classes and methods that a bundle can rely on.
- *Machine Processable* – It should be easy to process the specification with tools to verify bundles and Service Platforms.
- *Standards* – It should be based on standards as much as possible. It must be compatible with [71] *J2ME, Java 2 Micro Edition*.

#### 999.1.2 Entities

- *Execution Environment* – A collection of classes.
- *Class* – Contains a set of qualifiers and a set of signature for each method and field in that class.
- *Signature* – A unique identifier for the type associated with a field or the return type and argument types of a function.
- *Qualifiers* – A set of attributes that further define a signature.
- *Profile* – A SUN/JCP defined set of classes, based on a configuration.
- *Configuration* – A SUN/JCP defined set of classes and VM specification.

Figure 57      *Entities involved in an Execution Environment*



## 999.2      About Execution Environments

### 999.2.1      Signatures

An Execution Environment consists of a set of public and protected *signatures*. A signature is defined to be a unique identifier for a field or method with class and type information. For example, the signature of the `wait(long)` method in `Object` would be:

`java/lang/Object.wait(J)V`

The encoding of the signature is defined in [69] *The Java Virtual Machine Specification*.

For this specification, each signature includes a set of *qualifiers* that further qualify the field or method. These are the access qualifiers (like `public`, `private`, and `protected`), and informational qualifiers like `synchronized`, `volatile`, `strictfp`, `interface`, `native`, and `abstract`. These informational qualifiers are not included in the EE listings.

An Execution Environment consists of a set of classes and interfaces with their access qualifiers. Each class consist of a set of signatures.

### 999.2.2      Semantics

An Execution environment is solely based on the signatures of the methods and fields. An OSGi Execution Environment relies on the appropriate SUN Java documents to define the semantics of a methods or fields.

## 999.3      OSGi Defined Execution Environments

This specification contains two Execution Environments. They are listed in the following sections. Each signature is printed in the normal Java format except that public modifiers are not shown to save space (all fields or methods must be public or protected to be included in this list).

Before each signature there are two columns.

1. OSGi/Minimum-1.1 execution requirements
2. CDC-1.0/Foundation-1.0 execution environment.

If the column contains a ■, it means that the signature has been *included* in that Execution Environment. A □ indicates that the signature is missing from the EE.

The information is included here for completeness. However, it is likely that tools will be developed by vendors that validate the compliance of Service Platforms and bundles in relation to an Execution Environment. For that reason, it is possible to download a JAR file containing all the signatures as Java class files from the OSGi web site, see [70] *Downloadable Execution Environments*.

## 999.3.1

### java.io

|                                                                         |                                                                  |
|-------------------------------------------------------------------------|------------------------------------------------------------------|
| ■ ■ package java.io                                                     |                                                                  |
| ■ ■ class <b>BufferedInputStream</b> extends <b>FilterInputStream</b>   |                                                                  |
| ■ ■ BufferedInputStream(InputStream)                                    | ■ ■ protected int markpos                                        |
| ■ ■ BufferedInputStream(InputStream, int)                               | ■ ■ boolean markSupported()                                      |
| ■ ■ int available() throws IOException                                  | ■ ■ protected int pos                                            |
| ■ ■ protected byte[] buf                                                | ■ ■ int read() throws IOException                                |
| ■ ■ void close() throws IOException                                     | ■ ■ int read(byte[], int, int) throws IOException                |
| ■ ■ protected int count                                                 | ■ ■ void reset() throws IOException                              |
| ■ ■ void mark(int)                                                      | ■ ■ long skip(long) throws IOException                           |
| ■ ■ protected int marklimit                                             |                                                                  |
| ■ ■ class <b>BufferedOutputStream</b> extends <b>FilterOutputStream</b> |                                                                  |
| ■ ■ BufferedOutputStream(OutputStream)                                  | ■ ■ void flush() throws IOException                              |
| ■ ■ BufferedOutputStream(OutputStream, int)                             | ■ ■ void write(byte[], int, int) throws IOException              |
| ■ ■ protected byte[] buf                                                | ■ ■ void write(int) throws IOException                           |
| ■ ■ protected int count                                                 |                                                                  |
| ■ ■ class <b>BufferedReader</b> extends <b>Reader</b>                   |                                                                  |
| ■ ■ BufferedReader(Reader)                                              | ■ ■ int read(char[], int, int) throws IOException                |
| ■ ■ BufferedReader(Reader, int)                                         | ■ ■ String readLine() throws IOException                         |
| ■ ■ void close() throws IOException                                     | ■ ■ boolean ready() throws IOException                           |
| ■ ■ void mark(int) throws IOException                                   | ■ ■ void reset() throws IOException                              |
| ■ ■ boolean markSupported()                                             | ■ ■ long skip(long) throws IOException                           |
| ■ ■ int read() throws IOException                                       |                                                                  |
| ■ ■ class <b>BufferedWriter</b> extends <b>Writer</b>                   |                                                                  |
| ■ ■ BufferedWriter(Writer)                                              | ■ ■ void write(char[], int, int) throws IOException              |
| ■ ■ BufferedWriter(Writer, int)                                         | ■ ■ void write(int) throws IOException                           |
| ■ ■ void close() throws IOException                                     | ■ ■ void write(String, int, int) throws IOException              |
| ■ ■ void flush() throws IOException                                     |                                                                  |
| ■ ■ void newLine() throws IOException                                   |                                                                  |
| ■ ■ class <b>ByteArrayInputStream</b> extends <b>InputStream</b>        |                                                                  |
| ■ ■ ByteArrayInputStream(byte[])                                        | ■ ■ protected int mark                                           |
| ■ ■ ByteArrayInputStream(byte[], int, int)                              | ■ ■ boolean markSupported()                                      |
| ■ ■ int available()                                                     | ■ ■ protected int pos                                            |
| ■ ■ protected byte[] buf                                                | ■ ■ int read()                                                   |
| ■ ■ void close() throws IOException                                     | ■ ■ int read(byte[], int, int)                                   |
| ■ ■ protected int count                                                 | ■ ■ void reset()                                                 |
| ■ ■ void mark(int)                                                      | ■ ■ long skip(long)                                              |
| ■ ■ class <b>ByteArrayOutputStream</b> extends <b>OutputStream</b>      |                                                                  |
| ■ ■ ByteArrayOutputStream()                                             | ■ ■ String toString()                                            |
| ■ ■ ByteArrayOutputStream(int)                                          | □ ■ String toString(String) throws UnsupportedOperationException |
| ■ ■ protected byte[] buf                                                | ■ ■ void write(byte[], int, int)                                 |
| ■ ■ void close() throws IOException                                     | ■ ■ void write(int)                                              |
| ■ ■ protected int count                                                 | ■ ■ void writeTo(OutputStream) throws IOException                |
| ■ ■ void reset()                                                        |                                                                  |
| ■ ■ int size()                                                          |                                                                  |
| ■ ■ byte[] toByteArray()                                                |                                                                  |
| □ ■ class <b>CharArrayReader</b> extends <b>Reader</b>                  |                                                                  |
| □ ■ CharArrayReader(char[])                                             | □ ■ CharArrayReader(char[], int, int)                            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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| <ul style="list-style-type: none"> <li>□ ■ protected char[] buf</li> <li>□ ■ void close()</li> <li>□ ■ protected int count</li> <li>□ ■ void mark(int) throws IOException</li> <li>□ ■ protected int markedPos</li> <li>□ ■ boolean markSupported()</li> <li>□ ■ protected int pos</li> <li>□ ■ <b>class CharArrayWriter extends Writer</b></li> <li>□ ■ CharArrayWriter()</li> <li>□ ■ CharArrayWriter(int)</li> <li>□ ■ protected char[] buf</li> <li>□ ■ void close()</li> <li>□ ■ protected int count</li> <li>□ ■ void flush()</li> <li>□ ■ void reset()</li> <li>□ ■ <b>class CharConversionException extends IOException</b></li> <li>□ ■ CharConversionException()</li> <li>□ ■ <b>interface DataInput</b></li> <li>□ ■ abstract boolean readBoolean() throws IOException</li> <li>□ ■ abstract byte readByte() throws IOException</li> <li>□ ■ abstract char readChar() throws IOException</li> <li>□ ■ abstract double readDouble() throws IOException</li> <li>□ ■ abstract float readFloat() throws IOException</li> <li>□ ■ abstract void readFully(byte[]) throws IOException</li> <li>□ ■ abstract void readFully(byte[],int,int) throws IOException</li> <li>□ ■ abstract int readInt() throws IOException</li> <li>□ ■ <b>class DataInputStream extends FilterInputStream implements DataInput</b></li> <li>□ ■ DataInputStream(InputStream)</li> <li>□ ■ final int read(byte[]) throws IOException</li> <li>□ ■ final int read(byte[],int,int) throws IOException</li> <li>□ ■ final boolean readBoolean() throws IOException</li> <li>□ ■ final byte readByte() throws IOException</li> <li>□ ■ final char readChar() throws IOException</li> <li>□ ■ final double readDouble() throws IOException</li> <li>□ ■ final float readFloat() throws IOException</li> <li>□ ■ final void readFully(byte[]) throws IOException</li> <li>□ ■ final void readFully(byte[],int,int) throws IOException</li> <li>□ ■ final int readInt() throws IOException</li> <li>□ ■ <b>interface DataOutput</b></li> <li>□ ■ abstract void write(byte[]) throws IOException</li> <li>□ ■ abstract void write(byte[],int,int) throws IOException</li> <li>□ ■ abstract void write(int) throws IOException</li> <li>□ ■ abstract void writeBoolean(boolean) throws IOException</li> <li>□ ■ abstract void writeByte(int) throws IOException</li> <li>□ ■ abstract void writeBytes(String) throws IOException</li> <li>□ ■ abstract void writeChar(int) throws IOException</li> <li>□ ■ <b>class DataOutputStream extends FilterOutputStream implements DataOutput</b></li> <li>□ ■ DataOutputStream(OutputStream)</li> <li>□ ■ void flush() throws IOException</li> <li>□ ■ final int size()</li> <li>□ ■ void write(byte[],int,int) throws IOException</li> </ul> | <ul style="list-style-type: none"> <li>□ ■ int read() throws IOException</li> <li>□ ■ int read(char[],int,int) throws IOException</li> <li>□ ■ boolean ready() throws IOException</li> <li>□ ■ void reset() throws IOException</li> <li>□ ■ long skip(long) throws IOException</li> <li>□ ■ int size()</li> <li>□ ■ char[] toCharArray()</li> <li>□ ■ String toString()</li> <li>□ ■ void write(char[],int,int)</li> <li>□ ■ void write(int)</li> <li>□ ■ void write(String,int,int)</li> <li>□ ■ void writeTo(Writer) throws IOException</li> <li>□ ■ CharConversionException(String)</li> <li>□ ■ abstract String readLine() throws IOException</li> <li>□ ■ abstract long readLong() throws IOException</li> <li>□ ■ abstract short readShort() throws IOException</li> <li>□ ■ abstract int readUnsignedByte() throws IOException</li> <li>□ ■ abstract int readUnsignedShort() throws IOException</li> <li>□ ■ abstract String readUTF() throws IOException</li> <li>□ ■ abstract int skipBytes(int) throws IOException</li> <li>□ ■ final String readLine() throws IOException</li> <li>□ ■ final long readLong() throws IOException</li> <li>□ ■ final short readShort() throws IOException</li> <li>□ ■ final int readUnsignedByte() throws IOException</li> <li>□ ■ final int readUnsignedShort() throws IOException</li> <li>□ ■ final String readUTF() throws IOException</li> <li>□ ■ final static String readUTF(DataInput) throws IOException</li> <li>□ ■ final int skipBytes(int) throws IOException</li> <li>□ ■ abstract void writeChars(String) throws IOException</li> <li>□ ■ abstract void writeDouble(double) throws IOException</li> <li>□ ■ abstract void writeFloat(float) throws IOException</li> <li>□ ■ abstract void writeInt(int) throws IOException</li> <li>□ ■ abstract void writeLong(long) throws IOException</li> <li>□ ■ abstract void writeShort(int) throws IOException</li> <li>□ ■ abstract void writeUTF(String) throws IOException</li> <li>□ ■ void write(int) throws IOException</li> <li>□ ■ final void writeBoolean(boolean) throws IOException</li> <li>□ ■ final void writeByte(int) throws IOException</li> </ul> |
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- **final void writeBytes(String)** throws `IOException`
- **final void writeChar(int)** throws `IOException`
- **final void writeChars(String)** throws `IOException`
- **final void writeDouble(double)** throws `IOException`
- **final void writeFloat(float)** throws `IOException`
- **class EOFException extends IOException**
- **EOFException()**
- **interface Externalizable extends Serializable**
- **abstract void readExternal(ObjectInput)** throws `IOException`, `ClassNotFoundException`
- **class File implements Serializable, Comparable**
- **File(File,String)**
- **File(String)**
- **File(String,String)**
- **boolean canRead()**
- **boolean canWrite()**
- **int compareTo(File)**
- **int compareTo(Object)**
- **boolean createNewFile()** throws `IOException`
- **static File createTempFile(String,String)** throws `IOException`
- **static File createTempFile(String,String,File)** throws `IOException`
- **boolean delete()**
- **void deleteOnExit()**
- **boolean equals(Object)**
- **boolean exists()**
- **File getAbsolutePath()**
- **String getAbsolutePath()**
- **File getCanonicalFile()** throws `IOException`
- **String getCanonicalPath()** throws `IOException`
- **String getName()**
- **String getParent()**
- **File getParentFile()**
- **final class FileDescriptor**
- **FileDescriptor()**
- **final static FileDescriptor err**
- **final static FileDescriptor in**
- **interface FileFilter**
- **abstract boolean accept(File)**
- **class FileInputStream extends InputStream**
- **FileInputStream(File)** throws `FileNotFoundException`
- **FileInputStream(FileDescriptor)**
- **FileInputStream(String)** throws `FileNotFoundException`
- **int available()** throws `IOException`
- **void close()** throws `IOException`
- **protected void finalize()** throws `IOException`
- **interface FilenameFilter**
- **abstract boolean accept(File,String)**
- **class FileNotFoundException extends IOException**
- **FileNotFoundException()**
- **class FileOutputStream extends OutputStream**
- **FileOutputStream(File)** throws `FileNotFoundException`
- **FileOutputStream(FileDescriptor)**
- **FileOutputStream(String)** throws `FileNotFoundException`
- **FileOutputStream(String,boolean)** throws `FileNotFoundException`
- **final void writeInt(int)** throws `IOException`
- **final void writeLong(long)** throws `IOException`
- **final void writeShort(int)** throws `IOException`
- **final void writeUTF(String)** throws `IOException`
- **protected int written**
- **EOFException(String)**
- **abstract void writeExternal(ObjectOutput)** throws `IOException`
- **String getPath()**
- **int hashCode()**
- **boolean isAbsolute()**
- **boolean isDirectory()**
- **boolean isFile()**
- **boolean isHidden()**
- **long lastModified()**
- **long length()**
- **String[] list()**
- **String[] list(FilenameFilter)**
- **File[] listFiles()**
- **File[] listFiles(FileFilter)**
- **File[] listFiles(FilenameFilter)**
- **static File[] listRoots()**
- **boolean mkdir()**
- **boolean mkdirs()**
- **final static String pathSeparator**
- **final static char pathSeparatorChar**
- **boolean renameTo(File)**
- **final static String separator**
- **final static char separatorChar**
- **boolean setLastModified(long)**
- **boolean setReadOnly()**
- **String toString()**
- **java.net.URL toURL()** throws `java.net.MalformedURLException`
- **final static FileDescriptor out**
- **void sync()** throws `SyncFailedException`
- **boolean valid()**
- **final FileDescriptor getFD()** throws `IOException`
- **int read()** throws `IOException`
- **int read(byte[])** throws `IOException`
- **int read(byte[],int,int)** throws `IOException`
- **long skip(long)** throws `IOException`
- **FileNotFoundException(String)**
- **void close()** throws `IOException`
- **protected void finalize()** throws `IOException`
- **final FileDescriptor getFD()** throws `IOException`
- **void write(byte[])** throws `IOException`

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| <ul style="list-style-type: none"> <li>■ <b>void write(byte[],int,int) throws IOException</b></li> <li>■ <b>final class FilePermission extends java.security.Permission implements Serializable</b></li> <li>■ <b>FilePermission(String,String)</b></li> <li>■ <b>boolean equals(Object)</b></li> <li>■ <b>String getActions()</b></li> <li>■ <b>int hashCode()</b></li> <li>■ <b>class FileReader extends InputStreamReader</b></li> <li>■ <b>FileReader(File) throws FileNotFoundException</b></li> <li>■ <b>FileReader(FileDescriptor)</b></li> <li>■ <b>class FileWriter extends OutputStreamWriter</b></li> <li>■ <b>FileWriter(File) throws IOException</b></li> <li>■ <b>FileWriter(FileDescriptor)</b></li> <li>■ <b>FileWriter(String) throws IOException</b></li> <li>■ <b>class FilterInputStream extends InputStream</b></li> <li>■ <b>protected FilterInputStream(InputStream)</b></li> <li>■ <b>int available() throws IOException</b></li> <li>■ <b>void close() throws IOException</b></li> <li>■ <b>protected InputStream in</b></li> <li>■ <b>void mark(int)</b></li> <li>■ <b>boolean markSupported()</b></li> <li>■ <b>class FilterOutputStream extends OutputStream</b></li> <li>■ <b>FilterOutputStream(OutputStream)</b></li> <li>■ <b>void close() throws IOException</b></li> <li>■ <b>void flush() throws IOException</b></li> <li>■ <b>protected OutputStream out</b></li> <li>□ <b>abstract class FilterReader extends Reader</b></li> <li>□ <b>protected FilterReader(Reader)</b></li> <li>□ <b>void close() throws IOException</b></li> <li>□ <b>protected Reader in</b></li> <li>□ <b>void mark(int) throws IOException</b></li> <li>□ <b>boolean markSupported()</b></li> <li>□ <b>int read() throws IOException</b></li> <li>□ <b>abstract class FilterWriter extends Writer</b></li> <li>□ <b>protected FilterWriter(Writer)</b></li> <li>□ <b>void close() throws IOException</b></li> <li>□ <b>void flush() throws IOException</b></li> <li>□ <b>protected Writer out</b></li> <li>■ <b>abstract class InputStream</b></li> <li>■ <b>InputStream()</b></li> <li>■ <b>int available() throws IOException</b></li> <li>■ <b>void close() throws IOException</b></li> <li>■ <b>void mark(int)</b></li> <li>■ <b>boolean markSupported()</b></li> <li>■ <b>abstract int read() throws IOException</b></li> <li>■ <b>class InputStreamReader extends Reader</b></li> <li>■ <b>InputStreamReader(InputStream)</b></li> <li>■ <b>InputStreamReader(InputStream,String) throws UnsupportedOperationException</b></li> <li>■ <b>void close() throws IOException</b></li> <li>■ <b>String getEncoding()</b></li> <li>■ <b>class InterruptedIOException extends IOException</b></li> <li>■ <b>InterruptedIOException()</b></li> <li>■ <b>InterruptedIOException(String)</b></li> <li>■ <b>class InvalidClassException extends ObjectStreamException</b></li> <li>■ <b>InvalidClassException(String)</b></li> <li>■ <b>InvalidClassException(String,String)</b></li> <li>■ <b>class InvalidObjectException extends ObjectStreamException</b></li> <li>■ <b>InvalidObjectException(String)</b></li> <li>■ <b>class IOException extends Exception</b></li> <li>■ <b>IOException()</b></li> <li>■ <b>class LineNumberReader extends BufferedReader</b></li> <li>□ <b>LineNumberReader(Reader)</b></li> <li>□ <b>LineNumberReader(Reader,int)</b></li> <li>□ <b>int getLineNumber()</b></li> <li>□ <b>void mark(int) throws IOException</b></li> <li>□ <b>int read() throws IOException</b></li> </ul> | <ul style="list-style-type: none"> <li>■ <b>void write(int) throws IOException</b></li> <li>■ <b>boolean implies(java.security.Permission)</b></li> <li>■ <b>java.security.PermissionCollection newPermissionCollection()</b></li> <li>■ <b>FileReader(String) throws FileNotFoundException</b></li> <li>■ <b>FileWriter(String,boolean) throws IOException</b></li> <li>■ <b>int read() throws IOException</b></li> <li>■ <b>int read(byte[]) throws IOException</b></li> <li>■ <b>int read(byte[],int,int) throws IOException</b></li> <li>■ <b>void reset() throws IOException</b></li> <li>■ <b>long skip(long) throws IOException</b></li> <li>■ <b>void write(byte[]) throws IOException</b></li> <li>■ <b>void write(byte[],int,int) throws IOException</b></li> <li>■ <b>void write(int) throws IOException</b></li> <li>□ <b>int read(char[],int,int) throws IOException</b></li> <li>□ <b>boolean ready() throws IOException</b></li> <li>□ <b>void reset() throws IOException</b></li> <li>□ <b>long skip(long) throws IOException</b></li> <li>□ <b>void write(char[],int,int) throws IOException</b></li> <li>□ <b>void write(int) throws IOException</b></li> <li>□ <b>void write(String,int,int) throws IOException</b></li> <li>■ <b>int read(byte[]) throws IOException</b></li> <li>■ <b>int read(byte[],int,int) throws IOException</b></li> <li>■ <b>void reset() throws IOException</b></li> <li>■ <b>long skip(long) throws IOException</b></li> <li>■ <b>int read() throws IOException</b></li> <li>■ <b>int read(char[],int,int) throws IOException</b></li> <li>■ <b>boolean ready() throws IOException</b></li> <li>■ <b>int bytesTransferred</b></li> <li>■ <b>String classname</b></li> <li>■ <b>String getMessage()</b></li> <li>■ <b>IOException(String)</b></li> <li>□ <b>int read(char[],int,int) throws IOException</b></li> <li>□ <b>String readLine() throws IOException</b></li> <li>□ <b>void reset() throws IOException</b></li> <li>□ <b>void setLineNumber(int)</b></li> </ul> |
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383-432

# ObjectStreamConstants

- ■ protected ObjectOutputStream() throws IOException, SecurityException
- ■ ObjectOutputStream(OutputStream) throws IOException
- ■ protected void annotateClass(Class) throws IOException
- ■ protected void annotateProxyClass(Class) throws IOException
- ■ void close() throws IOException
- ■ void defaultWriteObject() throws IOException
- ■ protected void drain() throws IOException
- ■ protected boolean enableReplaceObject(boolean) throws SecurityException
- ■ void flush() throws IOException
- ■ ObjectOutputStream.PutField() throws IOException
- ■ protected Object replaceObject(Object) throws IOException
- ■ void reset() throws IOException
- ■ void useProtocolVersion(int) throws IOException
- ■ void write(byte[]) throws IOException
- ■ void write(byte[],int,int) throws IOException
- ■ void write(int) throws IOException
- ■ abstract class ObjectOutputStream.PutField
- ■ ObjectOutputStream.PutField()
- ■ abstract void put(String,byte)
- ■ abstract void put(String,char)
- ■ abstract void put(String,double)
- ■ abstract void put(String,float)
- ■ abstract void put(String,int)
- ■ class ObjectOutputStream implements Serializable
- ■ Class forClass()
- ■ ObjectOutputStream getField(String)
- ■ ObjectOutputStream[] getFields()
- ■ String getName()
- ■ long getSerialVersionUID()
- ■ interface ObjectStreamConstants
- ■ final static int baseWireHandle
- ■ final static int PROTOCOL\_VERSION\_1
- ■ final static int PROTOCOL\_VERSION\_2
- ■ final static byte SC\_BLOCK\_DATA
- ■ final static byte SC\_EXTERNALIZABLE
- ■ final static byte SC\_SERIALIZABLE
- ■ final static byte SC\_WRITE\_METHOD
- ■ final static short STREAM\_MAGIC
- ■ final static short STREAM\_VERSION
- ■ final static SerializablePermission SUBCLASS\_IMPLEMENTATION\_PERMISSION
- ■ final static SerializablePermission SUBSTITUTION\_PERMISSION
- ■ final static byte TC\_ARRAY
- ■ abstract class ObjectOutputStreamException extends IOException
- ■ protected ObjectOutputStreamException()
- ■ class ObjectOutputStreamField implements Comparable
- ■ ObjectOutputStreamField(String,Class)
- ■ int compareTo(Object)
- ■ String getName()
- ■ int getOffset()
- ■ Class getType()
- ■ class OptionalDataException extends ObjectOutputStreamException
- ■ boolean eof
- ■ abstract class OutputStream
- ■ OutputStream()
- ■ void close() throws IOException
- ■ void writeBoolean(boolean) throws IOException
- ■ void writeByte(int) throws IOException
- ■ void writeBytes(String) throws IOException
- ■ void writeChar(int) throws IOException
- ■ void writeChars(String) throws IOException
- ■ protected void writeClassDescriptor(ObjectStreamClass) throws IOException
- ■ void writeDouble(double) throws IOException
- ■ void writeFields() throws IOException
- ■ void writeFloat(float) throws IOException
- ■ void writeInt(int) throws IOException
- ■ void writeLong(long) throws IOException
- ■ final void writeObject(Object) throws IOException
- ■ protected void writeObjectOverride(Object) throws IOException
- ■ void writeShort(int) throws IOException
- ■ protected void writeStreamHeader() throws IOException
- ■ void writeUTF(String) throws IOException
- ■ abstract void put(String,long)
- ■ abstract void put(String,Object)
- ■ abstract void put(String,short)
- ■ abstract void put(String,boolean)
- ■ abstract void write(ObjectOutput) throws IOException
- ■ static ObjectOutputStream lookup(Class)
- ■ final static ObjectOutputStreamField[] NO\_FIELDS
- ■ String toString()
- ■ final static byte TC\_BASE
- ■ final static byte TC\_BLOCKDATA
- ■ final static byte TC\_BLOCKDATALONG
- ■ final static byte TC\_CLASS
- ■ final static byte TC\_CLASSDESC
- ■ final static byte TC\_ENDBLOCKDATA
- ■ final static byte TC\_EXCEPTION
- ■ final static byte TC\_LONGSTRING
- ■ final static byte TC\_MAX
- ■ final static byte TC\_NULL
- ■ final static byte TC\_OBJECT
- ■ final static byte TC\_PROXYCLASSDESC
- ■ final static byte TC\_REFERENCE
- ■ final static byte TC\_RESET
- ■ final static byte TC\_STRING
- ■ protected ObjectOutputStreamException(String)
- ■ char getTypeCode()
- ■ String getTypeString()
- ■ boolean isPrimitive()
- ■ protected void setOffset(int)
- ■ String toString()
- ■ int length
- ■ void flush() throws IOException
- ■ void write(byte[]) throws IOException

- **void write(byte[],int,int) throws IOException**
- **class OutputStreamWriter extends Writer**
- **OutputStreamWriter(OutputStream)**
- **OutputStreamWriter(OutputStream, String) throws UnsupportedOperationException**
- **void close() throws IOException**
- **void flush() throws IOException**
- **class PipedInputStream extends InputStream**
- **PipedInputStream()**
- **PipedInputStream(PipedOutputStream) throws IOException**
- **int available() throws IOException**
- **protected byte[] buffer**
- **void close() throws IOException**
- **void connect(PipedOutputStream) throws IOException**
- **class PipedOutputStream extends OutputStream**
- **PipedOutputStream()**
- **PipedOutputStream(PipedInputStream) throws IOException**
- **void close() throws IOException**
- **void connect(PipedInputStream) throws IOException**
- **class PipedReader extends Reader**
- **PipedReader()**
- **PipedReader(PipedWriter) throws IOException**
- **void close() throws IOException**
- **void connect(PipedWriter) throws IOException**
- **class PipedWriter extends Writer**
- **PipedWriter()**
- **PipedWriter(PipedReader) throws IOException**
- **void close() throws IOException**
- **void connect(PipedReader) throws IOException**
- **class PrintStream extends FilterOutputStream**
- **PrintStream(OutputStream)**
- **PrintStream(OutputStream,boolean)**
- **boolean checkError()**
- **void close()**
- **void flush()**
- **void print(char[])**
- **void print(char)**
- **void print(double)**
- **void print(float)**
- **void print(int)**
- **void print(long)**
- **void print(Object)**
- **void print(String)**
- **void print(boolean)**
- **class PrintWriter extends Writer**
- **PrintWriter(OutputStream)**
- **PrintWriter(OutputStream,boolean)**
- **PrintWriter(Writer)**
- **PrintWriter(Writer,boolean)**
- **boolean checkError()**
- **void close()**
- **void flush()**
- **protected Writer out**
- **void print(char[])**
- **void print(char)**
- **void print(double)**
- **void print(float)**
- **void print(int)**
- **void print(long)**
- **void print(Object)**
- **void print(String)**
- **abstract void write(int) throws IOException**
- **String getEncoding()**
- **void write(char[],int,int) throws IOException**
- **void write(int) throws IOException**
- **void write(String,int,int) throws IOException**
- **protected int in**
- **protected int out**
- **final protected static int PIPE\_SIZE**
- **int read() throws IOException**
- **int read(byte[],int,int) throws IOException**
- **protected void receive(int) throws IOException**
- **void flush() throws IOException**
- **void write(byte[],int,int) throws IOException**
- **void write(int) throws IOException**
- **int read() throws IOException**
- **int read(char[],int,int) throws IOException**
- **boolean ready() throws IOException**
- **void flush() throws IOException**
- **void write(char[],int,int) throws IOException**
- **void write(int) throws IOException**
- **void println()**
- **void println(char[])**
- **void println(char)**
- **void println(double)**
- **void println(float)**
- **void println(int)**
- **void println(long)**
- **void println(Object)**
- **void println(String)**
- **void println(boolean)**
- **protected void setError()**
- **void write(byte[],int,int)**
- **void write(int)**
- **void print(boolean)**
- **void println()**
- **void println(char[])**
- **void println(char)**
- **void println(double)**
- **void println(float)**
- **void println(int)**
- **void println(long)**
- **void println(Object)**
- **void println(String)**
- **void println(boolean)**
- **protected void setError()**
- **void write(char[])**
- **void write(char[],int,int)**
- **void write(int)**
- **void write(String)**

```

■ ■ void write(String,int,int)
■ ■ class PushbackInputStream extends FilterInputStream
■ ■ PushbackInputStream(InputStream)
■ ■ PushbackInputStream(InputStream,int)
■ ■ int available() throws IOException
■ ■ protected byte[] buf
■ ■ void close() throws IOException
■ ■ boolean markSupported()
■ ■ protected int pos
■ ■ int read() throws IOException
□ ■ class PushbackReader extends FilterReader
□ ■ PushbackReader(Reader)
□ ■ PushbackReader(Reader,int)
□ ■ void close() throws IOException
□ ■ void mark(int) throws IOException
□ ■ boolean markSupported()
□ ■ int read() throws IOException
□ ■ int read(char[],int,int) throws
 IOException
■ ■ class RandomAccessFile implements DataInput , DataOutput
■ ■ RandomAccessFile(File,String) throws
 FileNotFoundException
■ ■ RandomAccessFile(String,String) throws
 FileNotFoundException
■ ■ void close() throws IOException
■ ■ final FileDescriptor getFD() throws
 IOException
■ ■ long getFilePointer() throws IOException
■ ■ long length() throws IOException
■ ■ int read() throws IOException
■ ■ int read(byte[]) throws IOException
■ ■ int read(byte[],int,int) throws
 IOException
■ ■ final boolean readBoolean() throws
 IOException
■ ■ final byte readByte() throws IOException
■ ■ final char readChar() throws IOException
■ ■ final double readDouble() throws
 IOException
■ ■ final float readFloat() throws IOException
■ ■ final void readFully(byte[]) throws
 IOException
■ ■ final void readFully(byte[],int,int) throws
 IOException
■ ■ final int readInt() throws IOException
■ ■ final String readLine() throws
 IOException
■ ■ final long readLong() throws IOException
■ ■ final short readShort() throws
 IOException
■ ■ final int readUnsignedByte() throws
 IOException
■ ■ abstract class Reader
■ ■ protected Reader()
■ ■ protected Reader(Object)
■ ■ abstract void close() throws IOException
■ ■ protected Object lock
■ ■ void mark(int) throws IOException
■ ■ boolean markSupported()
■ ■ int read() throws IOException
□ ■ class SequenceInputStream extends InputStream
□ ■ SequenceInputStream(InputStream,
 InputStream)
□ ■ SequenceInputStream(java.util.Enumerati
 on)
■ ■ interface Serializable
■ ■ final class SerializablePermission extends java.security.BasicPermission
■ ■ SerializablePermission(String)
■ ■ SerializablePermission(String,String)
■ ■ class StreamCorruptedException extends ObjectStreamException
■ ■ int read(byte[],int,int) throws
 IOException
■ ■ long skip(long) throws IOException
■ ■ void unread(byte[]) throws IOException
■ ■ void unread(byte[],int,int) throws
 IOException
■ ■ void unread(int) throws IOException
□ ■ boolean ready() throws IOException
□ ■ void reset() throws IOException
□ ■ void unread(char[]) throws IOException
□ ■ void unread(char[],int,int) throws
 IOException
□ ■ void unread(int) throws IOException
■ ■ final int readUnsignedShort() throws
 IOException
■ ■ final String readUTF() throws
 IOException
■ ■ void seek(long) throws IOException
■ ■ void setLength(long) throws IOException
■ ■ int skipBytes(int) throws IOException
■ ■ void write(byte[]) throws IOException
■ ■ void write(byte[],int,int) throws
 IOException
■ ■ void write(int) throws IOException
■ ■ final void writeBoolean(boolean) throws
 IOException
■ ■ final void writeByte(int) throws
 IOException
■ ■ final void writeBytes(String) throws
 IOException
■ ■ final void writeChar(int) throws
 IOException
■ ■ final void writeChars(String) throws
 IOException
■ ■ final void writeDouble(double) throws
 IOException
■ ■ final void writeFloat(float) throws
 IOException
■ ■ final void writeInt(int) throws
 IOException
■ ■ final void writeLong(long) throws
 IOException
■ ■ final void writeShort(int) throws
 IOException
■ ■ final void writeUTF(String) throws
 IOException
■ ■ int read(char[]) throws IOException
■ ■ abstract int read(char[],int,int) throws
 IOException
■ ■ boolean ready() throws IOException
■ ■ void reset() throws IOException
■ ■ long skip(long) throws IOException
□ ■ int available() throws IOException
□ ■ void close() throws IOException
□ ■ int read() throws IOException
□ ■ int read(byte[],int,int) throws
 IOException

```

|                                                               |                                                |
|---------------------------------------------------------------|------------------------------------------------|
| ■ ■ StreamCorruptedException()                                | ■ ■ StreamCorruptedException(String)           |
| □ ■ class StreamTokenizer                                     | □ ■ void resetSyntax()                         |
| □ ■ StreamTokenizer(Reader)                                   | □ ■ void slashSlashComments(boolean)           |
| □ ■ void commentChar(int)                                     | □ ■ void slashStarComments(boolean)            |
| □ ■ void eolIsSignificant(boolean)                            | □ ■ String sval                                |
| □ ■ int lineno()                                              | □ ■ String toString()                          |
| □ ■ void lowerCaseMode(boolean)                               | □ ■ final static int TT_EOF                    |
| □ ■ int nextToken() throws IOException                        | □ ■ final static int TT_EOL                    |
| □ ■ double nval                                               | □ ■ final static int TT_NUMBER                 |
| □ ■ void ordinaryChar(int)                                    | □ ■ final static int TT_WORD                   |
| □ ■ void ordinaryChars(int,int)                               | □ ■ int ttype                                  |
| □ ■ void parseNumbers()                                       | □ ■ void whitespaceChars(int,int)              |
| □ ■ void pushBack()                                           | □ ■ void wordChars(int,int)                    |
| □ ■ void quoteChar(int)                                       |                                                |
| ■ ■ class StringReader extends Reader                         |                                                |
| ■ ■ StringReader(String)                                      | ■ ■ int read(char[],int,int) throws            |
| ■ ■ void close()                                              | IOException                                    |
| ■ ■ void mark(int) throws IOException                         | ■ ■ boolean ready() throws IOException         |
| ■ ■ boolean markSupported()                                   | ■ ■ void reset() throws IOException            |
| ■ ■ int read() throws IOException                             | ■ ■ long skip(long) throws IOException         |
| ■ ■ class StringWriter extends Writer                         |                                                |
| ■ ■ StringWriter()                                            | ■ ■ String toString()                          |
| ■ ■ StringWriter(int)                                         | ■ ■ void write(char[],int,int)                 |
| ■ ■ void close() throws IOException                           | ■ ■ void write(int)                            |
| ■ ■ void flush()                                              | ■ ■ void write(String)                         |
| ■ ■ StringBuffer getBuffer()                                  | ■ ■ void write(String,int,int)                 |
| ■ ■ class SyncFailedException extends IOException             |                                                |
| ■ ■ SyncFailedException(String)                               |                                                |
| ■ ■ class UnsupportedEncodingException extends IOException    |                                                |
| ■ ■ UnsupportedEncodingException()                            | ■ ■ UnsupportedEncodingException(String)       |
| ■ ■ class UTFDataFormatException extends IOException          |                                                |
| ■ ■ UTFDataFormatException()                                  | ■ ■ UTFDataFormatException(String)             |
| ■ ■ class WriteAbortedException extends ObjectStreamException |                                                |
| ■ ■ WriteAbortedException(String,Exception)                   | ■ ■ String getMessage()                        |
| ■ ■ Exception detail                                          |                                                |
| ■ ■ abstract class Writer                                     |                                                |
| ■ ■ protected Writer()                                        | ■ ■ abstract void write(char[],int,int) throws |
| ■ ■ protected Writer(Object)                                  | IOException                                    |
| ■ ■ abstract void close() throws IOException                  | ■ ■ void write(int) throws IOException         |
| ■ ■ abstract void flush() throws IOException                  | ■ ■ void write(String) throws IOException      |
| ■ ■ protected Object lock                                     | ■ ■ void write(String,int,int) throws          |
| ■ ■ void write(char[]) throws IOException                     | IOException                                    |

## 999.3.2

### java.lang

|                                                                            |                                            |
|----------------------------------------------------------------------------|--------------------------------------------|
| ■ ■ package java.lang                                                      |                                            |
| ■ ■ class AbstractMethodError extends IncompatibleClassChangeError         |                                            |
| ■ ■ AbstractMethodError()                                                  | ■ ■ AbstractMethodError(String)            |
| ■ ■ class ArithmeticException extends RuntimeException                     |                                            |
| ■ ■ ArithmeticException()                                                  | ■ ■ ArithmeticException(String)            |
| ■ ■ class ArrayIndexOutOfBoundsException extends IndexOutOfBoundsException |                                            |
| ■ ■ ArrayIndexOutOfBoundsException()                                       | ■ ■ ArrayIndexOutOfBoundsException(String) |
| ■ ■ ArrayIndexOutOfBoundsException(int)                                    |                                            |
| ■ ■ class ArrayStoreException extends RuntimeException                     |                                            |
| ■ ■ ArrayStoreException()                                                  | ■ ■ ArrayStoreException(String)            |
| ■ ■ final class Boolean implements java.io.Serializable                    |                                            |
| ■ ■ Boolean(String)                                                        | ■ ■ int hashCode()                         |
| ■ ■ Boolean(boolean)                                                       | ■ ■ String toString()                      |
| ■ ■ boolean booleanValue()                                                 | ■ ■ final static Boolean TRUE              |
| ■ ■ boolean equals(Object)                                                 | ■ ■ final static Class TYPE                |
| ■ ■ final static Boolean FALSE                                             | ■ ■ static Boolean valueOf(String)         |
| ■ ■ static boolean getBoolean(String)                                      |                                            |
| ■ ■ final class Byte extends Number implements Comparable                  |                                            |
| ■ ■ Byte(byte)                                                             | □ ■ static Byte decode(String) throws      |
| ■ ■ Byte(String) throws                                                    | NumberFormatException                      |
| ■ ■ byte byteValue()                                                       | ■ ■ double doubleValue()                   |
| ■ ■ int compareTo(Byte)                                                    | ■ ■ boolean equals(Object)                 |
| ■ ■ int compareTo(Object)                                                  | ■ ■ float floatValue()                     |
|                                                                            | ■ ■ int hashCode()                         |
|                                                                            | ■ ■ int intValue()                         |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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| <ul style="list-style-type: none"> <li>■ ■ long longValue()</li> <li>■ ■ final static byte MAX_VALUE</li> <li>■ ■ final static byte MIN_VALUE</li> <li>■ ■ static byte parseByte(String) throws<br/>    NumberFormatException</li> <li>■ ■ static byte parseByte(String,int) throws<br/>    NumberFormatException</li> <li>■ ■ short shortValue()</li> <li>■ ■ final class Character implements java.io.Serializable , Comparable</li> <li>■ ■ Character(char)</li> <li>■ ■ char charValue()</li> <li>■ ■ final static byte<br/>    COMBINING_SPACING_MARK</li> <li>■ ■ int compareTo(Character)</li> <li>■ ■ int compareTo(Object)</li> <li>■ ■ final static byte<br/>    CONNECTOR_PUNCTUATION</li> <li>■ ■ final static byte CONTROL</li> <li>■ ■ final static byte CURRENCY_SYMBOL</li> <li>■ ■ final static byte DASH_PUNCTUATION</li> <li>■ ■ final static byte DECIMAL_DIGIT_NUMBER</li> <li>■ ■ static int digit(char,int)</li> <li>■ ■ final static byte ENCLOSING_MARK</li> <li>■ ■ final static byte END_PUNCTUATION</li> <li>■ ■ boolean equals(Object)</li> <li>■ ■ static char forDigit(int,int)</li> <li>■ ■ final static byte FORMAT</li> <li>□ ■ static int getNumericValue(char)</li> <li>■ ■ static int getType(char)</li> <li>■ ■ int hashCode()</li> <li>□ ■ static boolean isDefined(char)</li> <li>■ ■ static boolean isDigit(char)</li> <li>□ ■ static boolean isIdentifierIgnorable(char)</li> <li>□ ■ static boolean isISOControl(char)</li> <li>□ ■ static boolean isJavaIdentifierPart(char)</li> <li>□ ■ static boolean isJavaIdentifierStart(char)</li> <li>■ ■ static boolean isLetter(char)</li> <li>■ ■ static boolean isLetterOrDigit(char)</li> <li>■ ■ static boolean isLowerCase(char)</li> <li>■ ■ static boolean isSpaceChar(char)</li> <li>□ ■ static boolean isTitleCase(char)</li> <li>□ ■ static boolean<br/>    isUnicodeIdentifierPart(char)</li> <li>□ ■ class Character.Subset</li> <li>□ ■ protected Character.Subset(String)</li> <li>□ ■ final boolean equals(Object)</li> <li>□ ■ final class Character.UnicodeBlock extends Character.Subset</li> <li>□ ■ final static Character.UnicodeBlock<br/>    ALPHABETIC_PRESENTATION_FORMS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    ARABIC</li> <li>□ ■ final static Character.UnicodeBlock<br/>    ARABIC_PRESENTATION_FORMS_A</li> <li>□ ■ final static Character.UnicodeBlock<br/>    ARABIC_PRESENTATION_FORMS_B</li> <li>□ ■ final static Character.UnicodeBlock<br/>    ARMENIAN</li> <li>□ ■ final static Character.UnicodeBlock<br/>    ARROWS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    BASIC_LATIN</li> <li>□ ■ final static Character.UnicodeBlock<br/>    BENGALI</li> <li>□ ■ final static Character.UnicodeBlock<br/>    BLOCK_ELEMENTS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    BOPOMOFO</li> <li>□ ■ final static Character.UnicodeBlock<br/>    BOX_DRAWING</li> <li>□ ■ final static Character.UnicodeBlock<br/>    CJK_COMPATIBILITY</li> </ul> | <ul style="list-style-type: none"> <li>■ ■ String toString()</li> <li>□ ■ static String toString(byte)</li> <li>■ ■ final static Class TYPE</li> <li>□ ■ static Byte valueOf(String) throws<br/>    NumberFormatException</li> <li>■ ■ static Byte valueOf(String,int) throws<br/>    NumberFormatException</li> <li>□ ■ static boolean<br/>    isUnicodeIdentifierStart(char)</li> <li>■ ■ static boolean isUpperCase(char)</li> <li>■ ■ static boolean isWhitespace(char)</li> <li>■ ■ final static byte LETTER_NUMBER</li> <li>■ ■ final static byte LINE_SEPARATOR</li> <li>■ ■ final static byte LOWERCASE_LETTER</li> <li>■ ■ final static byte MATH_SYMBOL</li> <li>■ ■ final static int MAX_RADIX</li> <li>■ ■ final static char MAX_VALUE</li> <li>■ ■ final static int MIN_RADIX</li> <li>■ ■ final static char MIN_VALUE</li> <li>■ ■ final static byte MODIFIER_LETTER</li> <li>■ ■ final static byte MODIFIER_SYMBOL</li> <li>■ ■ final static byte NON_SPACING_MARK</li> <li>■ ■ final static byte OTHER_LETTER</li> <li>■ ■ final static byte OTHER_NUMBER</li> <li>■ ■ final static byte OTHER_PUNCTUATION</li> <li>■ ■ final static byte OTHER_SYMBOL</li> <li>■ ■ final static byte PARAGRAPH_SEPARATOR</li> <li>■ ■ final static byte PRIVATE_USE</li> <li>■ ■ final static byte SPACE_SEPARATOR</li> <li>■ ■ final static byte START_PUNCTUATION</li> <li>■ ■ final static byte SURROGATE</li> <li>■ ■ final static byte TITLECASE_LETTER</li> <li>■ ■ static char toLowerCase(char)</li> <li>■ ■ String toString()</li> <li>□ ■ static char toTitleCase(char)</li> <li>■ ■ static char toUpperCase(char)</li> <li>■ ■ final static Class TYPE</li> <li>■ ■ final static byte UNASSIGNED</li> <li>■ ■ final static byte UPPERCASE_LETTER</li> <li>□ ■ final int hashCode()</li> <li>□ ■ final String toString()</li> <li>□ ■ final static Character.UnicodeBlock<br/>    CJK_COMPATIBILITY_FORMS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    CJK_COMPATIBILITY_IDEOGRAPHS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    CJK_SYMBOLS_AND_PUNCTUATION</li> <li>□ ■ final static Character.UnicodeBlock<br/>    CJK_UNIFIED_IDEOGRAPHS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    COMBINING_DIACRITICAL_MARKS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    COMBINING_HALF_MARKS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    COMBINING_MARKS_FOR_SYMBOLS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    CONTROL_PICTURES</li> <li>□ ■ final static Character.UnicodeBlock<br/>    CURRENCY_SYMBOLS</li> <li>□ ■ final static Character.UnicodeBlock<br/>    CYRILLIC</li> <li>□ ■ final static Character.UnicodeBlock<br/>    DEVANAGARI</li> <li>□ ■ final static Character.UnicodeBlock<br/>    DINGBATS</li> </ul> |
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- ❑ final static Character.UnicodeBlock ENCLOSED\_ALPHANUMERICS
- ❑ final static Character.UnicodeBlock ENCLOSED\_CJK\_LETTERS\_AND\_MONTHS
- ❑ final static Character.UnicodeBlock GENERAL\_PUNCTUATION
- ❑ final static Character.UnicodeBlock GEOMETRIC\_SHAPES
- ❑ final static Character.UnicodeBlock GEORGIAN
- ❑ final static Character.UnicodeBlock GREEK
- ❑ final static Character.UnicodeBlock GREEK\_EXTENDED
- ❑ final static Character.UnicodeBlock GUJARATI
- ❑ final static Character.UnicodeBlock GURMUKHI
- ❑ final static Character.UnicodeBlock HALFWIDTH\_AND\_FULLWIDTH\_FORMS
- ❑ final static Character.UnicodeBlock HANGUL\_COMPATIBILITY\_JAMO
- ❑ final static Character.UnicodeBlock HANGUL\_JAMO
- ❑ final static Character.UnicodeBlock HANGUL\_SYLLABLES
- ❑ final static Character.UnicodeBlock HEBREW
- ❑ final static Character.UnicodeBlock HIRAGANA
- ❑ final static Character.UnicodeBlock IPA\_EXTENSIONS
- ❑ final static Character.UnicodeBlock KANBUN
- ❑ final static Character.UnicodeBlock KANNADA
- ❑ final static Character.UnicodeBlock KATAKANA
- ❑ final static Character.UnicodeBlock LAO
- ❑ final static Character.UnicodeBlock LATIN\_1\_SUPPLEMENT
- ❑ final static Character.UnicodeBlock LATIN\_EXTENDED\_A
- ❑ final static Character.UnicodeBlock LATIN\_EXTENDED\_ADDITIONAL
- ❑ final static Character.UnicodeBlock LATIN\_EXTENDED\_B
- ❑ final static Character.UnicodeBlock LETTERLIKE\_SYMBOLS
- ❑ final static Character.UnicodeBlock MALAYALAM
- ❑ final static Character.UnicodeBlock MATHEMATICAL\_OPERATORS
- ❑ final static Character.UnicodeBlock MISCELLANEOUS\_SYMBOLS
- ❑ final static Character.UnicodeBlock MISCELLANEOUS\_TECHNICAL
- ❑ final static Character.UnicodeBlock NUMBER\_FORMS
- ❑ static Character.UnicodeBlock of(char)
- ❑ final static Character.UnicodeBlock OPTICAL\_CHARACTER\_RECOGNITION
- ❑ final static Character.UnicodeBlock ORIYA
- ❑ final static Character.UnicodeBlock PRIVATE\_USE\_AREA
- ❑ final static Character.UnicodeBlock SMALL\_FORM\_VARIANTS
- ❑ final static Character.UnicodeBlock SPACING\_MODIFIER\_LETTERS
- ❑ final static Character.UnicodeBlock SPECIALS
- ❑ final static Character.UnicodeBlock SUPERSCRIPTS\_AND\_SUBSCRIPTS
- ❑ final static Character.UnicodeBlock SURROGATES\_AREA
- ❑ final static Character.UnicodeBlock TAMIL
- ❑ final static Character.UnicodeBlock TELUGU
- ❑ final static Character.UnicodeBlock THAI
- ❑ final static Character.UnicodeBlock TIBETAN
- final class Class implements java.io.Serializable
- static Class forName(String) throws ClassNotFoundException
- static Class forName(String,boolean,ClassLoader) throws ClassNotFoundException
- Class[] getClasses()
- ClassLoader getClassLoader()
- Class getComponentType()
- Constructor getConstructor(Class[]) throws NoSuchMethodException, SecurityException
- Constructor[] getConstructors() throws SecurityException
- Class[] getDeclaredClasses() throws SecurityException
- Constructor getDeclaredConstructor(Class[]) throws NoSuchMethodException, SecurityException
- Constructor[] getDeclaredConstructors() throws SecurityException
- Field getDeclaredField(String) throws NoSuchFieldException, SecurityException
- Field[] getDeclaredFields() throws SecurityException
- Method getDeclaredMethod(String,Class[]) throws NoSuchMethodException, SecurityException
- Method[] getDeclaredMethods() throws SecurityException
- Class getDeclaringClass()
- Field getField(String) throws NoSuchFieldException, SecurityException
- Field[] getFields() throws SecurityException
- Class[] getInterfaces()
- Method getMethod(String,Class[]) throws NoSuchMethodException, SecurityException
- Method[] getMethods() throws SecurityException
- int getModifiers()
- String getName()
- ❑ Package getPackage()
- java.security.ProtectionDomain getProtectionDomain()
- java.net.URL getResource(String)
- java.io.InputStream getResourceAsStream(String)
- Object[] getSigners()
- Class getSuperclass()
- boolean isArray()
- boolean isAssignableFrom(Class)
- boolean isInstance(Object)
- boolean isInterface()
- boolean isPrimitive()

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| <ul style="list-style-type: none"> <li>■ ■ Object newInstance() throws<br/>IllegalAccessExceptio<br/>n, InstantiationExceptio</li> <li>■ ■ class ClassCastException extends RuntimeException</li> <li>■ ■ ClassCastException()</li> <li>■ ■ class ClassCircularityError extends LinkageError</li> <li>■ ■ ClassCircularityError()</li> <li>■ ■ class ClassFormatError extends LinkageError</li> <li>■ ■ ClassFormatError()</li> <li>■ ■ abstract class ClassLoader</li> <li>■ ■ protected ClassLoader()</li> <li>■ ■ protected ClassLoader(ClassLoader)</li> <li>■ ■ final protected Class defineClass(String,<br/>byte[],int,int) throws ClassFormatError</li> <li>■ ■ final protected Class defineClass(String,<br/>byte[],int,int,<br/>java.security.ProtectionDomain) throws<br/>ClassFormatError</li> <li>□ ■ protected Package definePackage(String,<br/>String,String,String,String,String,<br/>java.net.URL) throws<br/>IllegalArgumentException</li> <li>■ ■ protected Class findClass(String) throws<br/>ClassNotFoundException</li> <li>■ ■ protected String findLibrary(String)</li> <li>■ ■ final protected Class<br/>findLoadedClass(String)</li> <li>■ ■ protected java.net.URL<br/>findResource(String)</li> <li>■ ■ protected java.util.Enumeration<br/>findResources(String) throws<br/>java.io.IOException</li> <li>■ ■ final protected Class<br/>findSystemClass(String) throws<br/>ClassNotFoundException</li> <li>■ ■ class ClassNotFoundException extends Exception</li> <li>■ ■ ClassNotFoundException()</li> <li>■ ■ ClassNotFoundException(String)</li> <li>■ ■ ClassNotFoundException(String,<br/>Throwable)</li> <li>■ ■ interface Cloneable</li> <li>■ ■ class CloneNotSupportedException extends Exception</li> <li>■ ■ CloneNotSupportedException()</li> <li>■ ■ CloneNotSupportedException(String)</li> <li>■ ■ interface Comparable</li> <li>■ ■ abstract int compareTo(Object)</li> <li>□ ■ final class Compiler</li> <li>□ ■ static Object command(Object)</li> <li>□ ■ static boolean compileClass(Class)</li> <li>□ ■ static boolean compileClasses(String)</li> <li>■ ■ final class Double extends Number implements Comparable</li> <li>■ ■ Double(double)</li> <li>■ ■ Double(String) throws<br/>NumberFormatException</li> <li>■ ■ byte byteValue()</li> <li>■ ■ int compareTo(Double)</li> <li>■ ■ int compareTo(Object)</li> <li>■ ■ static long doubleToLongBits(double)</li> <li>□ ■ static long doubleToRawLongBits(double)</li> <li>■ ■ double doubleValue()</li> <li>■ ■ boolean equals(Object)</li> <li>■ ■ float floatValue()</li> <li>■ ■ int hashCode()</li> <li>■ ■ int intValue()</li> <li>■ ■ boolean isInfinite()</li> <li>■ ■ static boolean isInfinite(double)</li> <li>■ ■ boolean isNaN()</li> <li>■ ■ class Error extends Throwable</li> <li>■ ■ Error()</li> <li>■ ■ class Exception extends Throwable</li> <li>■ ■ Exception()</li> </ul> | <ul style="list-style-type: none"> <li>■ ■ String toString()</li> <li>■ ■ ClassCastException(String)</li> <li>■ ■ ClassCircularityError(String)</li> <li>■ ■ ClassFormatError(String)</li> <li>□ ■ protected Package getPackage(String)</li> <li>□ ■ protected Package[] getPackages()</li> <li>■ ■ final ClassLoader getParent()</li> <li>■ ■ java.net.URL getResource(String)</li> <li>■ ■ java.io.InputStream<br/>getResourceAsStream(String)</li> <li>■ ■ final java.util.Enumeration<br/>getResources(String) throws<br/>java.io.IOException</li> <li>■ ■ static ClassLoader<br/>getSystemClassLoader()</li> <li>■ ■ static java.net.URL<br/>getSystemResource(String)</li> <li>■ ■ static java.io.InputStream<br/>getSystemResourceAsStream(String)</li> <li>■ ■ static java.util.Enumeration<br/>getSystemResources(String) throws<br/>java.io.IOException</li> <li>■ ■ Class loadClass(String) throws<br/>ClassNotFoundException</li> <li>■ ■ protected Class loadClass(String,<br/>boolean) throws ClassNotFoundException</li> <li>■ ■ final protected void resolveClass(Class)</li> <li>■ ■ final protected void setSigners(Class,<br/>Object[])</li> <li>□ ■ Throwable getException()</li> <li>□ ■ void printStackTrace()</li> <li>■ ■ void printStackTrace(java.io.PrintStream)</li> <li>□ ■ void printStackTrace(java.io.PrintWriter)</li> <li>■ ■ CloneNotSupportedException(String)</li> <li>■ ■ static void disable()</li> <li>■ ■ static void enable()</li> <li>■ ■ static boolean isNaN(double)</li> <li>■ ■ static double longBitsToDouble(long)</li> <li>■ ■ long longValue()</li> <li>■ ■ final static double MAX_VALUE</li> <li>■ ■ final static double MIN_VALUE</li> <li>■ ■ final static double NaN</li> <li>■ ■ final static double NEGATIVE_INFINITY</li> <li>■ ■ static double parseDouble(String)<br/>throws NumberFormatException</li> <li>■ ■ final static double POSITIVE_INFINITY</li> <li>■ ■ short shortValue()</li> <li>■ ■ String toString()</li> <li>■ ■ static String toString(double)</li> <li>■ ■ final static Class TYPE</li> <li>■ ■ static Double valueOf(String) throws<br/>NumberFormatException</li> <li>■ ■ Error(String)</li> <li>■ ■ Exception(String)</li> </ul> |
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■ ■ class ExceptionInitializerError extends LinkageError
■ ■ ExceptionInitializerError()
■ ■ ExceptionInitializerError(String)
■ ■ ExceptionInitializerError(Throwable)
■ ■ Throwable getException()

■ ■ final class Float extends Number implements Comparable
■ ■ Float(double)
■ ■ Float(float)
■ ■ Float(String) throws
 NumberFormatException
■ ■ byte byteValue()
■ ■ int compareTo(Float)
■ ■ int compareTo(Object)
■ ■ double doubleValue()
■ ■ boolean equals(Object)
■ ■ static int floatToIntBits(float)
■ ■ static int floatToRawIntBits(float)
■ ■ float floatValue()
■ ■ int hashCode()
■ ■ static float intBitsToFloat(int)
■ ■ int intValue()
■ ■ boolean isInfinite()
■ ■ static boolean isInfinite(float)

■ ■ class IllegalAccessError extends IncompatibleClassChangeError
■ ■ IllegalAccessError()
■ ■ class IllegalAccessException extends Exception
■ ■ IllegalAccessException()

■ ■ class IllegalArgumentException extends RuntimeException
■ ■ IllegalArgumentException()

■ ■ class IllegalMonitorStateException extends RuntimeException
■ ■ IllegalMonitorStateException()

■ ■ class IllegalStateException extends RuntimeException
■ ■ IllegalStateException()

■ ■ class IllegalThreadStateException extends IllegalArgumentException
■ ■ IllegalThreadStateException()

■ ■ class IncompatibleClassChangeError extends LinkageError
■ ■ IncompatibleClassChangeError()

■ ■ class IndexOutOfBoundsException extends RuntimeException
■ ■ IndexOutOfBoundsException()

■ ■ class InheritableThreadLocal extends ThreadLocal
■ ■ InheritableThreadLocal()
■ ■ protected Object childValue(Object)

■ ■ class InstantiationException extends IncompatibleClassChangeError
■ ■ InstantiationException()

■ ■ class InstantiationException extends Exception
■ ■ InstantiationException()

■ ■ final class Integer extends Number implements Comparable
■ ■ Integer(int)
■ ■ Integer(String) throws
 NumberFormatException
■ ■ byte byteValue()
■ ■ int compareTo(Integer)
■ ■ int compareTo(Object)
■ ■ static Integer decode(String) throws
 NumberFormatException
■ ■ double doubleValue()
■ ■ boolean equals(Object)
■ ■ float floatValue()
■ ■ static Integer getInteger(String)
■ ■ static Integer getInteger(String,int)
■ ■ static Integer getInteger(String,Integer)
■ ■ int hashCode()
■ ■ int intValue()
■ ■ long longValue()
■ ■ final static int MAX_VALUE

■ ■ class InternalError extends VirtualMachineError
■ ■ InternalError()

■ ■ class InterruptedException extends Exception
■ ■ InterruptedException()

■ ■ class LinkageError extends Error
 ■ ■ void printStackTrace()
 ■ ■ void printStackTrace(java.io.PrintStream)
 ■ ■ void printStackTrace(java.io.PrintWriter)
 ■ ■ boolean isNaN()
 ■ ■ static boolean isNaN(float)
 ■ ■ long longValue()
 ■ ■ final static float MAX_VALUE
 ■ ■ final static float MIN_VALUE
 ■ ■ final static float NaN
 ■ ■ final static float NEGATIVE_INFINITY
 ■ ■ static float parseFloat(String) throws
 NumberFormatException
 ■ ■ final static float POSITIVE_INFINITY
 ■ ■ short shortValue()
 ■ ■ String toString()
 ■ ■ static String toString(float)
 ■ ■ final static Class TYPE
 ■ ■ static Float valueOf(String) throws
 NumberFormatException
 ■ ■ static int parseInt(String) throws
 NumberFormatException
 ■ ■ static int parseInt(String,int) throws
 NumberFormatException
 ■ ■ short shortValue()
 ■ ■ static String toBinaryString(int)
 ■ ■ static String toHexString(int)
 ■ ■ static String toOctalString(int)
 ■ ■ String toString()
 ■ ■ static String toString(int)
 ■ ■ static String toString(int,int)
 ■ ■ final static Class TYPE
 ■ ■ static Integer valueOf(String) throws
 NumberFormatException
 ■ ■ static Integer valueOf(String,int) throws
 NumberFormatException
 ■ ■ Object get()
 ■ ■ void set(Object)
 ■ ■ InstantiationException(String)
 ■ ■ IllegalStateException(String)
 ■ ■ IllegalArgumentException(String)
 ■ ■ IllegalAccessError(String)
 ■ ■ IllegalAccessException(String)
 ■ ■ IllegalThreadStateException(String)
 ■ ■ IncompatibleClassChangeError(String)
 ■ ■ IndexOutOfBoundsException(String)
 ■ ■ InstantiationException(String)
 ■ ■ InterruptedException(String)
 ■ ■ InternalError(String)
 ■ ■ InterruptedException(String)

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|                                                                                                         |                                                                                                             |
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| ■ ■ <code>LinkageError()</code>                                                                         | ■ ■ <code>LinkageError(String)</code>                                                                       |
| ■ ■ <b>final class <code>Long</code> extends <code>Number</code> implements <code>Comparable</code></b> |                                                                                                             |
| ■ ■ <code>Long(long)</code>                                                                             | ■ ■ <b>final static long <code>MIN_VALUE</code></b>                                                         |
| ■ ■ <code>Long(String)</code> throws<br><code>NumberFormatException</code>                              | ■ ■ <b>static long <code>parseLong(String)</code> throws<br/>    <code>NumberFormatException</code></b>     |
| ■ ■ <code>byte byteValue()</code>                                                                       | ■ ■ <b>static long <code>parseLong(String,int)</code> throws<br/>    <code>NumberFormatException</code></b> |
| ■ ■ <code>int compareTo(Long)</code>                                                                    | ■ ■ <code>short shortValue()</code>                                                                         |
| ■ ■ <code>int compareTo(Object)</code>                                                                  | ■ ■ <b>static String <code>toBinaryString(long)</code></b>                                                  |
| □ ■ <b>static long <code>decode(String)</code> throws<br/>    <code>NumberFormatException</code></b>    | ■ ■ <b>static String <code>toHexString(long)</code></b>                                                     |
| ■ ■ <code>double doubleValue()</code>                                                                   | □ ■ <b>static String <code>toOctalString(long)</code></b>                                                   |
| ■ ■ <code>boolean equals(Object)</code>                                                                 | ■ ■ <b>String <code>toString()</code></b>                                                                   |
| ■ ■ <code>float floatValue()</code>                                                                     | ■ ■ <b>static String <code>toString(long)</code></b>                                                        |
| □ ■ <b>static long <code>getLong(String)</code></b>                                                     | ■ ■ <b>static String <code>toString(long,int)</code></b>                                                    |
| □ ■ <b>static long <code>getLong(String,long)</code></b>                                                | ■ ■ <b>final static Class <code>TYPE</code></b>                                                             |
| □ ■ <b>static long <code>getLong(String,Long)</code></b>                                                | □ ■ <b>static long <code>valueOf(String)</code> throws<br/>    <code>NumberFormatException</code></b>       |
| ■ ■ <code>int hashCode()</code>                                                                         | ■ ■ <b>static long <code>valueOf(String,int)</code> throws<br/>    <code>NumberFormatException</code></b>   |
| ■ ■ <code>int intValue()</code>                                                                         |                                                                                                             |
| ■ ■ <code>long longValue()</code>                                                                       |                                                                                                             |
| ■ ■ <b>final static long <code>MAX_VALUE</code></b>                                                     |                                                                                                             |
| ■ ■ <b>final class <code>Math</code></b>                                                                |                                                                                                             |
| ■ ■ <b>static double <code>abs(double)</code></b>                                                       | ■ ■ <b>static int <code>max(int,int)</code></b>                                                             |
| ■ ■ <b>static float <code>abs(float)</code></b>                                                         | ■ ■ <b>static long <code>max(long,long)</code></b>                                                          |
| ■ ■ <b>static int <code>abs(int)</code></b>                                                             | ■ ■ <b>static double <code>min(double,double)</code></b>                                                    |
| ■ ■ <b>static long <code>abs(long)</code></b>                                                           | ■ ■ <b>static float <code>min(float,float)</code></b>                                                       |
| ■ ■ <b>static double <code>acos(double)</code></b>                                                      | ■ ■ <b>static int <code>min(int,int)</code></b>                                                             |
| ■ ■ <b>static double <code>asin(double)</code></b>                                                      | ■ ■ <b>static long <code>min(long,long)</code></b>                                                          |
| ■ ■ <b>static double <code>atan(double)</code></b>                                                      | ■ ■ <b>final static double <code>PI</code></b>                                                              |
| ■ ■ <b>static double <code>atan2(double,double)</code></b>                                              | ■ ■ <b>static double <code>pow(double,double)</code></b>                                                    |
| ■ ■ <b>static double <code>ceil(double)</code></b>                                                      | ■ ■ <b>static double <code>random()</code></b>                                                              |
| ■ ■ <b>static double <code>cos(double)</code></b>                                                       | ■ ■ <b>static double <code>rint(double)</code></b>                                                          |
| ■ ■ <b>final static double <code>E</code></b>                                                           | ■ ■ <b>static long <code>round(double)</code></b>                                                           |
| ■ ■ <b>static double <code>exp(double)</code></b>                                                       | ■ ■ <b>static int <code>round(float)</code></b>                                                             |
| ■ ■ <b>static double <code>floor(double)</code></b>                                                     | ■ ■ <b>static double <code>sin(double)</code></b>                                                           |
| ■ ■ <b>static double <code>IEEERemainder(double,<br/>    double)</code></b>                             | ■ ■ <b>static double <code>sqrt(double)</code></b>                                                          |
| ■ ■ <b>static double <code>log(double)</code></b>                                                       | ■ ■ <b>static double <code>tan(double)</code></b>                                                           |
| ■ ■ <b>static double <code>max(double,double)</code></b>                                                | ■ ■ <b>static double <code>toDegrees(double)</code></b>                                                     |
| ■ ■ <b>static float <code>max(float,float)</code></b>                                                   | ■ ■ <b>static double <code>toRadians(double)</code></b>                                                     |
| ■ ■ <b>class <code>NegativeArraySizeException</code> extends <code>RuntimeException</code></b>          |                                                                                                             |
| ■ ■ <code>NegativeArraySizeException()</code>                                                           | ■ ■ <b><code>NegativeArraySizeException(String)</code></b>                                                  |
| ■ ■ <b>class <code>NoClassDefFoundError</code> extends <code>LinkageError</code></b>                    |                                                                                                             |
| ■ ■ <code>NoClassDefFoundError()</code>                                                                 | ■ ■ <b><code>NoClassDefFoundError(String)</code></b>                                                        |
| ■ ■ <b>class <code>NoSuchFieldError</code> extends <code>IncompatibleClassChangeError</code></b>        |                                                                                                             |
| ■ ■ <code>NoSuchFieldError()</code>                                                                     | ■ ■ <b><code>NoSuchFieldError(String)</code></b>                                                            |
| ■ ■ <b>class <code>NoSuchFieldException</code> extends <code>Exception</code></b>                       |                                                                                                             |
| ■ ■ <code>NoSuchFieldException()</code>                                                                 | ■ ■ <b><code>NoSuchFieldException(String)</code></b>                                                        |
| ■ ■ <b>class <code>NoSuchMethodError</code> extends <code>IncompatibleClassChangeError</code></b>       |                                                                                                             |
| ■ ■ <code>NoSuchMethodError()</code>                                                                    | ■ ■ <b><code>NoSuchMethodError(String)</code></b>                                                           |
| ■ ■ <b>class <code>NoSuchMethodException</code> extends <code>Exception</code></b>                      |                                                                                                             |
| ■ ■ <code>NoSuchMethodException()</code>                                                                | ■ ■ <b><code>NoSuchMethodException(String)</code></b>                                                       |
| ■ ■ <b>class <code>NullPointerException</code> extends <code>RuntimeException</code></b>                |                                                                                                             |
| ■ ■ <code>NullPointerException()</code>                                                                 | ■ ■ <b><code>NullPointerException(String)</code></b>                                                        |
| ■ ■ <b>abstract class <code>Number</code> implements <code>java.io.Serializable</code></b>              |                                                                                                             |
| ■ ■ <code>Number()</code>                                                                               | ■ ■ <b>abstract int <code>intValue()</code></b>                                                             |
| ■ ■ <code>byte byteValue()</code>                                                                       | ■ ■ <b>abstract long <code>longValue()</code></b>                                                           |
| ■ ■ <b>abstract double <code>doubleValue()</code></b>                                                   | ■ ■ <b>short <code>shortValue()</code></b>                                                                  |
| ■ ■ <b>abstract float <code>floatValue()</code></b>                                                     |                                                                                                             |
| ■ ■ <b>class <code>NumberFormatException</code> extends <code>IllegalArgumentException</code></b>       |                                                                                                             |
| ■ ■ <code>NumberFormatException()</code>                                                                | ■ ■ <b><code>NumberFormatException(String)</code></b>                                                       |
| ■ ■ <b>class <code>Object</code></b>                                                                    |                                                                                                             |
| ■ ■ <code>Object()</code>                                                                               | ■ ■ <b>final void <code>notifyAll()</code></b>                                                              |
| ■ ■ <b>protected <code>Object clone()</code> throws<br/>    <code>CloneNotSupportedException</code></b> | ■ ■ <b>String <code>toString()</code></b>                                                                   |
| ■ ■ <b>boolean <code>equals(Object)</code></b>                                                          | ■ ■ <b>final void <code>wait()</code> throws<br/>    <code>InterruptedException</code></b>                  |
| ■ ■ <b>protected void <code>finalize()</code> throws<br/>    <code>Throwable</code></b>                 | ■ ■ <b>final void <code>wait(long)</code> throws<br/>    <code>InterruptedException</code></b>              |
| ■ ■ <b>final Class <code>getClass()</code></b>                                                          | ■ ■ <b>final void <code>wait(long,int)</code> throws<br/>    <code>InterruptedException</code></b>          |
| ■ ■ <b>int <code>hashCode()</code></b>                                                                  |                                                                                                             |
| ■ ■ <b>final void <code>notify()</code></b>                                                             |                                                                                                             |

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■ ■ class OutOfMemoryError extends VirtualMachineError
■ ■ OutOfMemoryError()
■ ■ OutOfMemoryError(String)

□ ■ class Package
□ ■ String getImplementationTitle()
□ ■ String getImplementationVendor()
□ ■ String getImplementationVersion()
□ ■ String getName()
□ ■ static Package getPackage(String)
□ ■ static Package[] getPackages()
□ ■ String getSpecificationTitle()
□ ■ String getSpecificationVendor()

■ ■ abstract class Process
■ ■ Process()
■ ■ abstract void destroy()
■ ■ abstract int exitValue()
■ ■ abstract java.io.InputStream
 getErrorStream()

■ ■ interface Runnable
■ ■ abstract void run()

■ ■ class Runtime
□ ■ void addShutdownHook(Thread)
■ ■ Process exec(String[]) throws
 java.io.IOException
■ ■ Process exec(String[],String[]) throws
 java.io.IOException
□ ■ Process exec(String[],String[],
 java.io.File) throws java.io.IOException
■ ■ Process exec(String) throws
 java.io.IOException
■ ■ Process exec(String,String[]) throws
 java.io.IOException
□ ■ Process exec(String,String[],java.io.File)
 throws java.io.IOException

■ ■ class RuntimeException extends Exception
■ ■ RuntimeException()
■ ■ RuntimeException(String)

■ ■ final class RuntimePermission extends java.security.BasicPermission
■ ■ RuntimePermission(String)
■ ■ RuntimePermission(String,String)

■ ■ class SecurityException extends RuntimeException
■ ■ SecurityException()
■ ■ SecurityException(String)

■ ■ class SecurityManager
■ ■ SecurityManager()
■ ■ void checkAccept(String,int)
■ ■ void checkAccess(Thread)
■ ■ void checkAccess(ThreadGroup)
■ ■ void checkAwtEventQueueAccess()
■ ■ void checkConnect(String,int)
■ ■ void checkConnect(String,int,Object)
■ ■ void checkCreateClassLoader()
■ ■ void checkDelete(String)
■ ■ void checkExec(String)
■ ■ void checkExit(int)
■ ■ void checkLink(String)
■ ■ void checkListen(int)
■ ■ void checkMemberAccess(Class,int)
■ ■ void
 checkMulticast(java.net.InetAddress)
■ ■ void checkMulticast(java.net.InetAddress,
 byte)
■ ■ void checkPackageAccess(String)
■ ■ void checkPackageDefinition(String)

■ ■ final class Short extends Number implements Comparable
■ ■ Short(String) throws
 NumberFormatException
■ ■ Short(short)
■ ■ byte byteValue()
■ ■ int compareTo(Object)
■ ■ int compareTo(Short)
□ ■ static Short decode(String) throws
 NumberFormatException

■ ■ void exit(int)
■ ■ long freeMemory()
■ ■ void gc()
■ ■ static Runtime getRuntime()
□ ■ void halt(int)
■ ■ void load(String)
■ ■ void loadLibrary(String)
□ ■ boolean removeShutdownHook(Thread)
■ ■ void runFinalization()
■ ■ long totalMemory()
□ ■ void traceInstructions(boolean)
□ ■ void traceMethodCalls(boolean)

■ ■ String getSpecificationVersion()
■ ■ int hashCode()
■ ■ boolean isCompatibleWith(String)
 throws NumberFormatException
■ ■ boolean isSealed()
■ ■ boolean isSealed(java.net.URL)
■ ■ String toString()

■ ■ abstract java.io.InputStream
 getInputStream()
■ ■ abstract java.io.OutputStream
 getOutputStream()
■ ■ abstract int waitFor() throws
 InterruptedException

■ ■ void checkPermission(java.security.Permission
)
■ ■ void
 checkPermission(java.security.Permission
 ,Object)
■ ■ void checkPrintJobAccess()
■ ■ void checkPropertiesAccess()
■ ■ void checkPropertyAccess(String)
■ ■ void checkRead(java.io.FileDescriptor)
■ ■ void checkRead(String)
■ ■ void checkRead(String,Object)
■ ■ void checkSecurityAccess(String)
■ ■ void checkSetFactory()
■ ■ void checkSystemClipboardAccess()
■ ■ boolean checkTopLevelWindow(Object)
■ ■ void checkWrite(java.io.FileDescriptor)
■ ■ void checkWrite(String)
■ ■ protected Class[] getClassContext()
■ ■ Object getSecurityContext()
■ ■ ThreadGroup getThreadGroup()

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| <ul style="list-style-type: none"> <li>■ ■ static short parseShort(String) throws NumberFormatException</li> <li>■ ■ static short parseShort(String,int) throws NumberFormatException</li> <li>■ ■ short shortValue()</li> <li>■ ■ String toString()</li> <li>■ ■ class StackOverflowError extends VirtualMachineError</li> <li>■ ■ StackOverflowError()</li> <li>■ ■ StackOverflowError(String)</li> <li>□ ■ final class StrictMath</li> <li>□ ■ static double abs(double)</li> <li>□ ■ static float abs(float)</li> <li>□ ■ static int abs(int)</li> <li>□ ■ static long abs(long)</li> <li>□ ■ static double acos(double)</li> <li>□ ■ static double asin(double)</li> <li>□ ■ static double atan(double)</li> <li>□ ■ static double atan2(double,double)</li> <li>□ ■ static double ceil(double)</li> <li>□ ■ static double cos(double)</li> <li>□ ■ final static double E</li> <li>□ ■ static double exp(double)</li> <li>□ ■ static double floor(double)</li> <li>□ ■ static double IEEERemainder(double, double)</li> <li>□ ■ static double log(double)</li> <li>□ ■ static double max(double,double)</li> <li>□ ■ static float max(float,float)</li> <li>■ ■ final class String implements java.io.Serializable , Comparable</li> <li>■ ■ String()</li> <li>■ ■ String(byte[])</li> <li>■ ■ String(byte[],int,int)</li> <li>■ ■ String(byte[],int,int,String) throws java.io.UnsupportedEncodingException</li> <li>■ ■ String(byte[],String) throws java.io.UnsupportedEncodingException</li> <li>■ ■ String(char[])</li> <li>■ ■ String(char[],int,int)</li> <li>■ ■ String(String)</li> <li>■ ■ String(StringBuffer)</li> <li>■ ■ final static java.util.Comparator CASE_INSENSITIVE_ORDER</li> <li>■ ■ char charAt(int)</li> <li>■ ■ int compareTo(Object)</li> <li>■ ■ int compareTo(String)</li> <li>■ ■ int compareToIgnoreCase(String)</li> <li>■ ■ String concat(String)</li> <li>□ ■ static String copyValueOf(char[])</li> <li>□ ■ static String copyValueOf(char[],int,int)</li> <li>■ ■ boolean endsWith(String)</li> <li>■ ■ boolean equals(Object)</li> <li>■ ■ boolean equalsIgnoreCase(String)</li> <li>■ ■ byte[] getBytes()</li> <li>■ ■ byte[] getBytes(String) throws java.io.UnsupportedEncodingException</li> <li>■ ■ void getChars(int,int,char[],int)</li> <li>■ ■ int hashCode()</li> <li>■ ■ int indexOf(int)</li> <li>■ ■ int indexOf(int,int)</li> <li>■ ■ int indexOf(String)</li> <li>■ ■ final class StringBuffer implements java.io.Serializable</li> <li>■ ■ StringBuffer()</li> <li>■ ■ StringBuffer(int)</li> <li>■ ■ StringBuffer(String)</li> <li>■ ■ StringBuffer append(char[])</li> <li>■ ■ StringBuffer append(char[],int,int)</li> <li>■ ■ StringBuffer append(char)</li> <li>■ ■ StringBuffer append(double)</li> <li>■ ■ StringBuffer append(float)</li> <li>■ ■ StringBuffer append(int)</li> <li>■ ■ StringBuffer append(long)</li> <li>■ ■ StringBuffer append(Object)</li> </ul> | <ul style="list-style-type: none"> <li>□ ■ static String toString(short)</li> <li>■ ■ final static Class TYPE</li> <li>□ ■ static Short valueOf(String) throws NumberFormatException</li> <li>■ ■ static Short valueOf(String,int) throws NumberFormatException</li> <li>□ ■ static int max(int,int)</li> <li>□ ■ static long max(long,long)</li> <li>□ ■ static double min(double,double)</li> <li>□ ■ static float min(float,float)</li> <li>□ ■ static int min(int,int)</li> <li>□ ■ static long min(long,long)</li> <li>□ ■ final static double PI</li> <li>□ ■ static double pow(double,double)</li> <li>□ ■ static double random()</li> <li>□ ■ static double rint(double)</li> <li>□ ■ static long round(double)</li> <li>□ ■ static int round(float)</li> <li>□ ■ static double sin(double)</li> <li>□ ■ static double sqrt(double)</li> <li>□ ■ static double tan(double)</li> <li>□ ■ static double toDegrees(double)</li> <li>□ ■ static double toRadians(double)</li> <li>■ ■ int indexOf(String,int)</li> <li>■ ■ String intern()</li> <li>■ ■ int lastIndexOf(int)</li> <li>■ ■ int lastIndexOf(int,int)</li> <li>■ ■ int lastIndexOf(String)</li> <li>■ ■ int lastIndexOf(String,int)</li> <li>■ ■ int length()</li> <li>■ ■ boolean regionMatches(int,String,int,int)</li> <li>■ ■ boolean regionMatches(boolean,int, String,int,int)</li> <li>■ ■ String replace(char,char)</li> <li>■ ■ boolean startsWith(String)</li> <li>■ ■ boolean startsWith(String,int)</li> <li>■ ■ String substring(int)</li> <li>■ ■ String substring(int,int)</li> <li>■ ■ char[] toCharArray()</li> <li>■ ■ String toLowerCase()</li> <li>■ ■ String toLowerCase(java.util.Locale)</li> <li>■ ■ String toString()</li> <li>■ ■ String toUpperCase()</li> <li>■ ■ String toUpperCase(java.util.Locale)</li> <li>■ ■ String trim()</li> <li>■ ■ static String valueOf(char[])</li> <li>■ ■ static String valueOf(char[],int,int)</li> <li>■ ■ static String valueOf(char)</li> <li>■ ■ static String valueOf(double)</li> <li>■ ■ static String valueOf(float)</li> <li>■ ■ static String valueOf(int)</li> <li>■ ■ static String valueOf(long)</li> <li>■ ■ static String valueOf(Object)</li> <li>■ ■ static String valueOf(boolean)</li> <li>■ ■ StringBuffer append(String)</li> <li>■ ■ StringBuffer append(boolean)</li> <li>■ ■ int capacity()</li> <li>■ ■ char charAt(int)</li> <li>■ ■ StringBuffer delete(int,int)</li> <li>■ ■ StringBuffer deleteCharAt(int)</li> <li>■ ■ void ensureCapacity(int)</li> <li>■ ■ void getChars(int,int,char[],int)</li> <li>■ ■ StringBuffer insert(int,char[])</li> <li>□ ■ StringBuffer insert(int,char[],int,int)</li> <li>■ ■ StringBuffer insert(int,char)</li> </ul> |
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| <ul style="list-style-type: none"> <li>■ ■ StringBuffer insert(int,double)</li> <li>■ ■ StringBuffer insert(int,float)</li> <li>■ ■ StringBuffer insert(int,int)</li> <li>■ ■ StringBuffer insert(int,long)</li> <li>■ ■ StringBuffer insert(int,Object)</li> <li>■ ■ StringBuffer insert(int,String)</li> <li>■ ■ StringBuffer insert(int,boolean)</li> <li>■ ■ int length()</li> <li>■ ■ class StringIndexOutOfBoundsException extends IndexOutOfBoundsException</li> <li>■ ■ StringIndexOutOfBoundsException()</li> <li>■ ■ StringIndexOutOfBoundsException(int)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"> <li>□ ■ StringBuffer replace(int,int,String)</li> <li>■ ■ StringBuffer reverse()</li> <li>■ ■ void setCharAt(int,char)</li> <li>■ ■ void setLength(int)</li> <li>□ ■ String substring(int)</li> <li>■ ■ String substring(int,int)</li> <li>■ ■ String toString()</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <ul style="list-style-type: none"> <li>■ ■ final class System</li> <li>■ ■ static void arraycopy(Object,int,Object, int,int)</li> <li>■ ■ static long currentTimeMillis()</li> <li>■ ■ final static java.io.PrintStream err</li> <li>■ ■ static void exit(int)</li> <li>■ ■ static void gc()</li> <li>■ ■ static java.util.Properties getProperties()</li> <li>■ ■ static String getProperty(String)</li> <li>■ ■ static String getProperty(String,String)</li> <li>■ ■ static SecurityManager getSecurityManager()</li> <li>■ ■ static int identityHashCode(Object)</li> <li>■ ■ final static java.io.InputStream in</li> <li>■ ■ class Thread implements Runnable</li> <li>■ ■ Thread()</li> <li>■ ■ Thread(Runnable)</li> <li>■ ■ Thread(Runnable,String)</li> <li>■ ■ Thread(String)</li> <li>■ ■ Thread(ThreadGroup,Runnable)</li> <li>■ ■ Thread(ThreadGroup,Runnable,String)</li> <li>■ ■ Thread(ThreadGroup,String)</li> <li>■ ■ static int activeCount()</li> <li>■ ■ final void checkAccess()</li> <li>■ ■ static Thread currentThread()</li> <li>□ ■ void destroy()</li> <li>□ ■ static void dumpStack()</li> <li>□ ■ static int enumerate(Thread[])</li> <li>■ ■ ClassLoader getContextClassLoader()</li> <li>■ ■ final String getName()</li> <li>■ ■ final int getPriority()</li> <li>■ ■ final ThreadGroup getThreadGroup()</li> <li>■ ■ void interrupt()</li> <li>■ ■ static boolean interrupted()</li> <li>■ ■ final boolean isAlive()</li> <li>■ ■ final boolean isDaemon()</li> <li>■ ■ boolean isInterrupted()</li> <li>■ ■ class ThreadDeath extends Error</li> <li>■ ■ ThreadDeath()</li> <li>■ ■ class ThreadGroup</li> <li>■ ■ ThreadGroup(String)</li> <li>■ ■ ThreadGroup(ThreadGroup,String)</li> <li>■ ■ int activeCount()</li> <li>■ ■ int activeGroupCount()</li> <li>■ ■ final void checkAccess()</li> <li>■ ■ final void destroy()</li> <li>■ ■ int enumerate(Thread[])</li> <li>■ ■ int enumerate(Thread[],boolean)</li> <li>■ ■ int enumerate(ThreadGroup[])</li> <li>■ ■ int enumerate(ThreadGroup[],boolean)</li> <li>■ ■ final int getMaxPriority()</li> <li>■ ■ final String getName()</li> <li>■ ■ class ThreadLocal</li> <li>■ ■ ThreadLocal()</li> <li>■ ■ Object get()</li> <li>■ ■ class Throwable implements java.io.Serializable</li> <li>■ ■ Throwable()</li> <li>■ ■ Throwable(String)</li> <li>■ ■ Throwable fillInStackTrace()</li> </ul> | <ul style="list-style-type: none"> <li>■ ■ StringIndexOutOfBoundsException(String )</li> <li>□ ■ static void load(String)</li> <li>■ ■ static void loadLibrary(String)</li> <li>■ ■ static String mapLibraryName(String)</li> <li>■ ■ final static java.io.PrintStream out</li> <li>■ ■ static void runFinalization()</li> <li>■ ■ static void setErr(java.io.PrintStream)</li> <li>■ ■ static void setIn(java.io.InputStream)</li> <li>■ ■ static void setOut(java.io.PrintStream)</li> <li>■ ■ static void setProperties(java.util.Properties)</li> <li>□ ■ static String setProperty(String,String)</li> <li>■ ■ static void setSecurityManager(SecurityManager)</li> <li>■ ■ final void join() throws InterruptedException</li> <li>■ ■ final void join(long) throws InterruptedException</li> <li>■ ■ final void join(long,int) throws InterruptedException</li> <li>■ ■ final static int MAX_PRIORITY</li> <li>■ ■ final static int MIN_PRIORITY</li> <li>■ ■ final static int NORM_PRIORITY</li> <li>■ ■ void run()</li> <li>■ ■ void setContextClassLoader(ClassLoader)</li> <li>■ ■ final void setDaemon(boolean)</li> <li>■ ■ final void setName(String)</li> <li>■ ■ final void setPriority(int)</li> <li>■ ■ static void sleep(long) throws InterruptedException</li> <li>■ ■ static void sleep(long,int) throws InterruptedException</li> <li>■ ■ void start()</li> <li>■ ■ String toString()</li> <li>■ ■ static void yield()</li> <li>■ ■ final ThreadGroup getParent()</li> <li>□ ■ final void interrupt()</li> <li>■ ■ final boolean isDaemon()</li> <li>■ ■ boolean isDestroyed()</li> <li>■ ■ void list()</li> <li>■ ■ final boolean parentOf(ThreadGroup)</li> <li>■ ■ final void setDaemon(boolean)</li> <li>■ ■ final void setMaxPriority(int)</li> <li>■ ■ String toString()</li> <li>■ ■ void uncaughtException(Thread, Throwable)</li> <li>■ ■ protected Object initialValue()</li> <li>■ ■ void set(Object)</li> <li>■ ■ String getLocalizedMessage()</li> <li>■ ■ String getMessage()</li> <li>■ ■ void printStackTrace()</li> </ul> |

- ■ void printStackTrace(java.io.PrintStream)
- ■ void printStackTrace(java.io.PrintWriter)
- ■ class **UnknownError** extends **VirtualMachineError**
- ■ UnknownError()
- ■ UnknownError(String)
- ■ class **UnsatisfiedLinkError** extends **LinkageError**
- ■ UnsatisfiedLinkError()
- ■ UnsatisfiedLinkError(String)
- ■ class **UnsupportedClassVersionError** extends **ClassFormatError**
- ■ UnsupportedClassVersionError()
- ■ UnsupportedClassVersionError(String)
- ■ class **UnsupportedOperationException** extends **RuntimeException**
- ■ UnsupportedOperationException()
- ■ UnsupportedOperationException(String)
- ■ class **VerifyError** extends **LinkageError**
- ■ VerifyError()
- ■ VerifyError(String)
- ■ abstract class **VirtualMachineError** extends **Error**
- ■ VirtualMachineError()
- ■ VirtualMachineError(String)
- ■ final class **Void**
- ■ final static Class TYPE

### 999.3.3

#### java.lang.ref

- ■ package **java.lang.ref**
- ■ class **PhantomReference** extends **Reference**
- ■ PhantomReference(Object, ReferenceQueue)
- ■ Object get()
- ■ abstract class **Reference**
- ■ void clear()
- ■ Object get()
- ■ boolean enqueue()
- ■ boolean isEnqueued()
- ■ class **ReferenceQueue**
- ■ ReferenceQueue()
- ■ Reference poll()
- ■ Reference remove() throws InterruptedException
- ■ Reference remove(long) throws InterruptedException, IllegalArgumentException, InterruptedException
- ■ class **SoftReference** extends **Reference**
- ■ SoftReference(Object)
- ■ SoftReference(Object, ReferenceQueue)
- ■ Object get()
- ■ class **WeakReference** extends **Reference**
- ■ WeakReference(Object)
- ■ WeakReference(Object, ReferenceQueue)

### 999.3.4

#### java.lang.reflect

- ■ package **java.lang.reflect**
- ■ class **AccessibleObject**
- ■ protected AccessibleObject()
- ■ boolean isAccessible()
- ■ void setAccessible(boolean) throws SecurityException
- ■ void setAccessible(AccessibleObject[], boolean) throws SecurityException
- ■ static void setAccessible(AccessibleObject[], boolean) throws SecurityException
- ■ final class **Array**
- ■ static Object get(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static boolean getBoolean(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static byte getByte(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static char getChar(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static double getDouble(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static float getFloat(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static int getInt(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static int getLength(Object) throws IllegalArgumentException
- ■ static long getLong(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static short getShort(Object, int) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static Object newInstance(Class, int[]) throws NegativeArraySizeException, IllegalArgumentException
- ■ static Object newInstance(Class, int) throws NegativeArraySizeException
- ■ static void set(Object, int, Object) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static void setBoolean(Object, int, boolean) throws IllegalArgumentException, ArrayIndexOutOfBoundsException
- ■ static void setByte(Object, int, byte) throws IllegalArgumentException, ArrayIndexOutOfBoundsException

- **static void setChar(Object,int,char)**  
throws `IllegalArgumentException`,  
`ArrayIndexOutOfBoundsException`
- **static void setDouble(Object,int,double)**  
throws `IllegalArgumentException`,  
`ArrayIndexOutOfBoundsException`
- **static void setFloat(Object,int,float)**  
throws `IllegalArgumentException`,  
`ArrayIndexOutOfBoundsException`
- **final class Constructor extends AccessibleObject implements Member**
- **boolean equals(Object)**
- **Class getDeclaringClass()**
- **Class[] getExceptionTypes()**
- **int getModifiers()**
- **String getName()**
- **Class[] getParameterTypes()**
- **int hashCode()**
- **final class Field extends AccessibleObject implements Member**
- **boolean equals(Object)**
- **Object get(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **boolean getBoolean(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **byte getByte(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **char getChar(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **Class getDeclaringClass()**
- **double getDouble(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **float getFloat(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **int getInt(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **long getLong(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **int getModifiers()**
- **String getName()**
- **short getShort(Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **interface InvocationHandler**
- **abstract Object invoke(Object,Method,  
Object[])** throws `Throwable`
- **class InvocationTargetException extends Exception**
- **protected InvocationTargetException()**
- **InvocationTargetException(Throwable)**
- **InvocationTargetException(Throwable,  
String)**
- **interface Member**
- **final static int DECLARED**
- **abstract Class getDeclaringClass()**
- **abstract int getModifiers()**
- **final class Method extends AccessibleObject implements Member**
- **boolean equals(Object)**
- **Class getDeclaringClass()**
- **Class[] getExceptionTypes()**
- **int getModifiers()**
- **String getName()**
- **Class[] getParameterTypes()**
- **Class getReturnType()**
- **class Modifier**
- **Modifier()**
- **static void setInt(Object,int,int)** throws  
`IllegalArgumentException`,  
`ArrayIndexOutOfBoundsException`
- **static void setLong(Object,int,long)**  
throws `IllegalArgumentException`,  
`ArrayIndexOutOfBoundsException`
- **static void setShort(Object,int,short)**  
throws `IllegalArgumentException`,  
`ArrayIndexOutOfBoundsException`
- **Object newInstance(Object[])** throws  
`InstantiationException`,  
`IllegalAccessException`,  
`IllegalArgumentException`,  
`InvocationTargetException`
- **String toString()**
- **Class getType()**
- **int hashCode()**
- **void set(Object,Object)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **void setBoolean(Object,boolean)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **void setByte(Object,byte)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **void setChar(Object,char)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **void setDouble(Object,double)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **void setFloat(Object,float)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **void setInt(Object,int)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **void setLong(Object,long)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **void setShort(Object,short)** throws  
`IllegalAccessException`,  
`IllegalArgumentException`
- **String toString()**
- **Throwable getTargetException()**
- **void printStackTrace()**
- **void printStackTrace(java.io.PrintStream)**
- **void printStackTrace(java.io.PrintWriter)**
- **abstract String getName()**
- **final static int PUBLIC**
- **int hashCode()**
- **Object invoke(Object,Object[])** throws  
`IllegalAccessException`,  
`IllegalArgumentException`,  
`InvocationTargetException`
- **String toString()**
- **final static int ABSTRACT**

```

■ ■ final static int FINAL
■ ■ final static int INTERFACE
■ ■ static boolean isAbstract(int)
■ ■ static boolean isFinal(int)
■ ■ static boolean isInterface(int)
■ ■ static boolean isNative(int)
■ ■ static boolean isPrivate(int)
■ ■ static boolean isProtected(int)
■ ■ static boolean isPublic(int)
■ ■ static boolean isStatic(int)
■ ■ static boolean isStrict(int)
■ ■ static boolean isSynchronized(int)
■ ■ class Proxy implements java.io.Serializable
■ ■ protected Proxy(InvocationHandler)
■ ■ static InvocationHandler
 getInvocationHandler(Object) throws
 IllegalArgumentException
■ ■ static Class getProxyClass(ClassLoader,
 Class[]) throws IllegalArgumentException
■ ■ final class ReflectPermission extends java.security.BasicPermission
■ ■ ReflectPermission(String)
■ ■ ReflectPermission(String,String)
■ ■ class UndeclaredThrowableException extends RuntimeException
■ ■ UndeclaredThrowableException(Throwable
 e)
■ ■ UndeclaredThrowableException(Throwable
 e,String)
■ ■ static boolean isTransient(int)
■ ■ static boolean isVolatile(int)
■ ■ final static int NATIVE
■ ■ final static int PRIVATE
■ ■ final static int PROTECTED
■ ■ final static int PUBLIC
■ ■ final static int STATIC
■ ■ final static int STRICT
■ ■ final static int SYNCHRONIZED
■ ■ static String toString(int)
■ ■ final static int TRANSIENT
■ ■ final static int VOLATILE
■ ■ protected InvocationHandler h
■ ■ static boolean isProxyClass(Class)
■ ■ static Object
 newProxyInstance(ClassLoader,Class[],
 InvocationHandler) throws
 IllegalArgumentException

```

## 999.3.5

### java.math

```

□ ■ package java.math
□ ■ class BigInteger extends Number implements Comparable
□ ■ BigInteger(byte[])
□ ■ BigInteger(int,byte[])
□ ■ BigInteger(int,int,java.util.Random)
□ ■ BigInteger(int,java.util.Random)
□ ■ BigInteger(String)
□ ■ BigInteger(String,int)
□ ■ BigInteger abs()
□ ■ BigInteger add(BigInteger)
□ ■ BigInteger and(BigInteger)
□ ■ BigInteger andNot(BigInteger)
□ ■ int bitCount()
□ ■ int bitLength()
□ ■ BigInteger clearBit(int)
□ ■ int compareTo(Object)
□ ■ int compareTo(BigInteger)
□ ■ BigInteger divide(BigInteger)
□ ■ BigInteger[]
 divideAndRemainder(BigInteger)
□ ■ double doubleValue()
□ ■ boolean equals(Object)
□ ■ BigInteger flipBit(int)
□ ■ float floatValue()
□ ■ BigInteger gcd(BigInteger)
□ ■ int getLowestSetBit()
□ ■ int hashCode()
□ ■ int intValue()
□ ■ boolean isProbablePrime(int)
□ ■ long longValue()
□ ■ BigInteger max(BigInteger)
□ ■ BigInteger min(BigInteger)
□ ■ BigInteger mod(BigInteger)
□ ■ BigInteger modInverse(BigInteger)
□ ■ BigInteger modPow(BigInteger,
 BigInteger)
□ ■ BigInteger multiply(BigInteger)
□ ■ BigInteger negate()
□ ■ BigInteger not()
□ ■ final static BigInteger ONE
□ ■ BigInteger or(BigInteger)
□ ■ BigInteger pow(int)
□ ■ BigInteger remainder(BigInteger)
□ ■ BigInteger setBit(int)
□ ■ BigInteger shiftLeft(int)
□ ■ BigInteger shiftRight(int)
□ ■ int signum()
□ ■ BigInteger subtract(BigInteger)
□ ■ boolean testBit(int)
□ ■ byte[] toByteArray()
□ ■ String toString()
□ ■ String toString(int)
□ ■ static BigInteger valueOf(long)
□ ■ BigInteger xor(BigInteger)
□ ■ final static BigInteger ZERO

```

## 999.3.6

### java.net

```

■ ■ package java.net
■ ■ abstract class Authenticator
■ ■ Authenticator()
■ ■ protected PasswordAuthentication
 getPasswordAuthentication()
■ ■ final protected int getRequestingPort()
■ ■ final protected String
 getRequestingPrompt()
■ ■ final protected String
 getRequestingProtocol()
■ ■ final protected String
 getRequestingScheme()
■ ■ final protected InetAddress
 getRequestingSite()

```



- **static** PasswordAuthentication requestPasswordAuthentication(InetAddress, int, String, String, String)
- **class** BindException **extends** SocketException
- BindException()
- BindException(String)
- **class** ConnectException **extends** SocketException
- ConnectException()
- ConnectException(String)
- **abstract class** ContentHandler
- ContentHandler()
- **abstract** Object getContent(URLConnection) throws java.io.IOException
- **interface** ContentHandlerFactory
- **abstract** ContentHandler createContentHandler(String)
- **final class** DatagramPacket
- DatagramPacket(byte[], int)
- DatagramPacket(byte[], int, int)
- DatagramPacket(byte[], int, int, InetAddress, int)
- DatagramPacket(byte[], int, InetAddress, int)
- InetAddress getAddress()
- byte[] getData()
- **class** DatagramSocket
- DatagramSocket() throws SocketException
- DatagramSocket(int) throws SocketException
- DatagramSocket(int, InetAddress) throws SocketException
- void close()
- void connect(InetAddress, int)
- void disconnect()
- InetAddress getInetAddress()
- InetAddress getLocalAddress()
- int getLocalPort()
- int getPort()
- int getReceiveBufferSize() throws SocketException
- int getSendBufferSize() throws SocketException
- **abstract class** DatagramSocketImpl **implements** SocketOptions
- DatagramSocketImpl()
- **abstract** protected void bind(int, InetAddress) throws SocketException
- **abstract** protected void close()
- **abstract** protected void create() throws SocketException
- protected java.io.FileDescriptor fd
- protected java.io.FileDescriptor getFileDescriptor()
- protected int getLocalPort()
- **abstract** Object getOption(int) throws SocketException
- **abstract** protected int getTimeout() throws java.io.IOException
- **abstract** protected void join(InetAddress) throws java.io.IOException
- **interface** DatagramSocketImplFactory
- **abstract** DatagramSocketImpl createDatagramSocketImpl()
- **interface** FileNameMap
- **abstract** String getContentTypeFor(String)
- **abstract class** HttpURLConnection **extends** URLConnection
- protected HttpURLConnection(URL)
- **abstract** void disconnect()
- java.io.InputStream getErrorStream()
- **static** void setDefault(Authenticator)
- int getLength()
- int getOffset()
- int getPort()
- void setAddress(InetAddress)
- void setData(byte[])
- void setData(byte[], int, int)
- void setLength(int)
- void setPort(int)
- int getSoTimeout() throws SocketException
- void receive(DatagramPacket) throws java.io.IOException
- void send(DatagramPacket) throws java.io.IOException
- **static** void setDatagramSocketImplFactory(DatagramSocketImplFactory) throws java.io.IOException
- void setReceiveBufferSize(int) throws SocketException
- void setSendBufferSize(int) throws SocketException
- void setSoTimeout(int) throws SocketException
- **abstract** protected void leave(InetAddress) throws java.io.IOException
- protected int localPort
- **abstract** protected int peek(InetAddress) throws java.io.IOException
- **abstract** protected void receive(DatagramPacket) throws java.io.IOException
- **abstract** protected void send(DatagramPacket) throws java.io.IOException
- **abstract** void setOption(int, Object) throws SocketException
- **abstract** protected void setTimeToLive(int) throws java.io.IOException
- **static** boolean getFollowRedirects()
- long getHeaderFieldDate(String, long)
- boolean getInstanceFollowRedirects()

```

■ ■ java.security.Permission getPermission()
 throws java.io.IOException
■ ■ String getRequestMethod()
■ ■ int getResponseCode() throws
 java.io.IOException
■ ■ String getResponseMessage() throws
 java.io.IOException
■ ■ final static int HTTP_ACCEPTED
■ ■ final static int HTTP_BAD_GATEWAY
■ ■ final static int HTTP_BAD_METHOD
■ ■ final static int HTTP_BAD_REQUEST
■ ■ final static int HTTP_CLIENT_TIMEOUT
■ ■ final static int HTTP_CONFLICT
■ ■ final static int HTTP_CREATED
■ ■ final static int HTTP_ENTITY_TOO_LARGE
■ ■ final static int HTTP_FORBIDDEN
■ ■ final static int HTTP_GATEWAY_TIMEOUT
■ ■ final static int HTTP_GONE
■ ■ final static int HTTP_INTERNAL_ERROR
■ ■ final static int HTTP_LENGTH_REQUIRED
■ ■ final static int HTTP_MOVED_PERM
■ ■ final static int HTTP_MOVED_TEMP
■ ■ final static int HTTP_MULT_CHOICE
■ ■ final static int HTTP_NO_CONTENT
■ ■ final static int HTTP_NOT_ACCEPTABLE
■ ■ final static int
 HTTP_NOT_AUTHENTICATED
■ ■ final static int HTTP_NOT_FOUND
■ ■ final class InetAddress implements java.io.Serializable
■ ■ boolean equals(Object)
■ ■ byte[] getAddress()
■ ■ static InetAddress[]
 getAllByName(String) throws
 UnknownHostException
■ ■ static InetAddress getByAddress(String)
 throws UnknownHostException
■ ■ abstract class JarURLConnection extends URLConnection
■ ■ protected JarURLConnection(URL)
 throws MalformedURLException
□ ■ java.util.jar.Attributes getAttributes()
 throws java.io.IOException
□ ■ java.security.cert.Certificate[]
 getCertificates() throws
 java.io.IOException
■ ■ String getEntryName()
□ ■ java.util.jar.JarEntry getJarEntry() throws
 java.io.IOException
■ ■ class MalformedURLException extends java.io.IOException
■ ■ MalformedURLException()
■ ■ MalformedURLException(String)
■ ■ class MulticastSocket extends DatagramSocket
■ ■ MulticastSocket() throws
 java.io.IOException
■ ■ MulticastSocket(int) throws
 java.io.IOException
■ ■ InetAddress getInterface() throws
 SocketException
■ ■ int getTimeToLive() throws
 java.io.IOException
■ ■ void joinGroup(InetAddress) throws
 java.io.IOException
■ ■ final class NetPermission extends java.security.BasicPermission
■ ■ NetPermission(String)
■ ■ NetPermission(String,String)
■ ■ class NoRouteToHostException extends SocketException
■ ■ NoRouteToHostException()
■ ■ NoRouteToHostException(String)
■ ■ final class PasswordAuthentication
■ ■ PasswordAuthentication(String,char[])
■ ■ char[] getPassword()
■ ■ String getUsername()
■ ■ class ProtocolException extends java.io.IOException
■ ■ ProtocolException()
■ ■ ProtocolException(String)
■ ■ class ServerSocket
■ ■ ServerSocket(int) throws
 java.io.IOException
■ ■ final static int HTTP_NOT_IMPLEMENTED
■ ■ final static int HTTP_NOT_MODIFIED
■ ■ final static int HTTP_OK
■ ■ final static int HTTP_PARTIAL
■ ■ final static int
 HTTP_PAYMENT_REQUIRED
■ ■ final static int HTTP_PRECON_FAILED
■ ■ final static int HTTP_PROXY_AUTH
■ ■ final static int HTTP_REQ_TOO_LONG
■ ■ final static int HTTP_RESET
■ ■ final static int HTTP_SEE_OTHER
■ ■ final static int HTTP_UNAUTHORIZED
■ ■ final static int HTTP_UNAVAILABLE
■ ■ final static int
 HTTP_UNSUPPORTED_TYPE
■ ■ final static int HTTP_USE_PROXY
■ ■ final static int HTTP_VERSION
□ ■ protected boolean
 instanceFollowRedirects
■ ■ protected String method
■ ■ protected int responseCode
■ ■ protected String responseMessage
■ ■ static void setFollowRedirects(boolean)
□ ■ void
 setInstanceFollowRedirects(boolean)
■ ■ void setRequestMethod(String) throws
 ProtocolException
■ ■ abstract boolean usingProxy()
■ ■ String getHostAddress()
■ ■ String getHostName()
■ ■ static InetAddress getLocalHost() throws
 UnknownHostException
■ ■ int hashCode()
■ ■ boolean isMulticastAddress()
■ ■ String toString()
□ ■ abstract java.util.jar.JarFile getJarFile()
 throws java.io.IOException
■ ■ URL getJarFileURL()
□ ■ java.util.jar.Attributes
 getMainAttributes() throws
 java.io.IOException
□ ■ java.util.jar.Manifest getManifest()
 throws java.io.IOException
■ ■ protected URLConnection
 jarFileURLConnection
■ ■ void leaveGroup(InetAddress) throws
 java.io.IOException
■ ■ void send(DatagramPacket,byte) throws
 java.io.IOException
■ ■ void setInterface(InetAddress) throws
 SocketException
■ ■ void setTimeToLive(int) throws
 java.io.IOException

```

- **ServerSocket(int,int)** throws java.io.IOException
- **ServerSocket(int,int,InetAddress)** throws java.io.IOException
- **Socket accept()** throws java.io.IOException
- **void close()** throws java.io.IOException
- **InetAddress getInetAddress()**
- **int getLocalPort()**
- **class Socket**
- **protected Socket()**
- **Socket(String,int)** throws UnknownHostException, java.io.IOException
- **Socket(String,int,InetAddress,int)** throws java.io.IOException
- **Socket(InetAddress,int)** throws java.io.IOException
- **Socket(InetAddress,int,InetAddress,int)** throws java.io.IOException
- **protected Socket(SocketImpl)** throws SocketException
- **void close()** throws java.io.IOException
- **InetAddress getInetAddress()**
- **java.io.InputStream getInputStream()** throws java.io.IOException
- **boolean getKeepAlive()** throws SocketException
- **InetAddress getLocalAddress()**
- **int getLocalPort()**
- **java.io.OutputStream getOutputStream()** throws java.io.IOException
- **int getPort()**
- **int getReceiveBufferSize()** throws SocketException
- **int getSendBufferSize()** throws SocketException
- **class SocketException extends java.io.IOException**
- **SocketException()**
- **abstract class SocketImpl implements SocketOptions**
- **SocketImpl()**
- **abstract protected void accept(SocketImpl)** throws java.io.IOException
- **protected InetAddress address**
- **abstract protected int available()** throws java.io.IOException
- **abstract protected void bind(InetAddress, int)** throws java.io.IOException
- **abstract protected void close()** throws java.io.IOException
- **abstract protected void connect(String, int)** throws java.io.IOException
- **abstract protected void connect(InetAddress, int)** throws java.io.IOException
- **abstract protected void create(boolean)** throws java.io.IOException
- **protected java.io.FileDescriptor fd**
- **protected java.io.FileDescriptor getFileDescriptor()**
- **protected InetAddress getInetAddress()**
- **interface SocketImplFactory**
- **abstract SocketImpl createSocketImpl()**
- **interface SocketOptions**
- **abstract Object getOption(int)** throws SocketException
- **final static int IP\_MULTICAST\_IF**
- **abstract void setOption(int, Object)** throws SocketException
- **int getSoTimeout()** throws java.io.IOException
- **final protected void implAccept(Socket)** throws java.io.IOException
- **static void setSocketFactory(SocketImplFactory)** throws java.io.IOException
- **void setSoTimeout(int)** throws SocketException
- **String toString()**
- **int getSolinger()** throws SocketException
- **int getSoTimeout()** throws SocketException
- **boolean getTcpNoDelay()** throws SocketException
- **void setKeepAlive(boolean)** throws SocketException
- **void setReceiveBufferSize(int)** throws SocketException
- **void setSendBufferSize(int)** throws SocketException
- **static void setSocketImplFactory(SocketImplFactory)** throws java.io.IOException
- **void setSolinger(boolean, int)** throws SocketException
- **void setSoTimeout(int)** throws SocketException
- **void setTcpNoDelay(boolean)** throws SocketException
- **void shutdownInput()** throws java.io.IOException
- **void shutdownOutput()** throws java.io.IOException
- **String toString()**
- **SocketException(String)**
- **abstract protected java.io.InputStream getInputStream()** throws java.io.IOException
- **protected int getLocalPort()**
- **abstract Object getOption(int)** throws SocketException
- **abstract protected java.io.OutputStream getOutputStream()** throws java.io.IOException
- **protected int getPort()**
- **abstract protected void listen(int)** throws java.io.IOException
- **protected int localport**
- **protected int port**
- **abstract void setOption(int, Object)** throws SocketException
- **protected void shutdownInput()** throws java.io.IOException
- **protected void shutdownOutput()** throws java.io.IOException
- **String toString()**
- **final static int SO\_BINDADDR**
- **final static int SO\_KEEPAIVE**
- **final static int SO\_LINGER**
- **final static int SO\_RCVBUF**
- **final static int SO\_REUSEADDR**

```

■ ■ final static int SO_SNDBUF
■ ■ final static int SO_TIMEOUT
■ ■ final class SocketPermission extends java.security.Permission implements java.io.Serializable
■ ■ SocketPermission(String,String)
■ ■ boolean equals(Object)
■ ■ String getActions()
■ ■ int hashCode()
■ ■ class UnknownHostException extends java.io.IOException
■ ■ UnknownHostException()
■ ■ UnknownHostException(String)
■ ■ class UnknownServiceException extends java.io.IOException
■ ■ UnknownServiceException()
■ ■ UnknownServiceException(String)
■ ■ final class URL implements java.io.Serializable
■ ■ URL(String) throws
 MalformedURLException
■ ■ URL(String,String,int,String) throws
 MalformedURLException
■ ■ URL(String,String,int,String,
 URLStreamHandler) throws
 MalformedURLException
■ ■ URL(String,String,String) throws
 MalformedURLException
■ ■ URL(URL,String) throws
 MalformedURLException
■ ■ URL(URL,String,URLStreamHandler)
 throws MalformedURLException
■ ■ boolean equals(Object)
■ ■ String getAuthority()
■ ■ final Object getContent() throws
 java.io.IOException
□ ■ final Object getContent(Class[]) throws
 java.io.IOException
■ ■ String getFile()
■ ■ String.getHost()
■ ■ class URLClassLoader extends java.security.SecureClassLoader
■ ■ URLClassLoader(URL[])
■ ■ URLClassLoader(URL[],ClassLoader)
■ ■ URLClassLoader(URL[],ClassLoader,
 URLStreamHandlerFactory)
■ ■ protected void addURL(URL)
□ ■ protected Package definePackage(String,
 java.util.jar.Manifest,URL) throws
 IllegalArgumentException
■ ■ protected Class findClass(String) throws
 ClassNotFoundException
■ ■ URL findResource(String)

■ ■ abstract class URLConnection
■ ■ protected URLConnection(URL)
■ ■ protected boolean allowUserInteraction
■ ■ abstract void connect() throws
 java.io.IOException
■ ■ protected boolean connected
■ ■ protected boolean doInput
■ ■ protected boolean doOutput
■ ■ boolean getAllowUserInteraction()
■ ■ Object getContent() throws
 java.io.IOException
□ ■ Object getContent(Class[]) throws
 java.io.IOException
■ ■ String getContentEncoding()
■ ■ int getContentLength()
■ ■ String getContentType()
■ ■ long getDate()
■ ■ static boolean
 getDefaultAllowUserInteraction()
■ ■ boolean getDefaultUseCaches()
■ ■ boolean getDoInput()
■ ■ boolean getDoOutput()
■ ■ long getExpiration()
■ ■ static FileNameMap getFileNameMap()
■ ■ String getHeaderField(int)

■ ■ final static int TCP_NODELAY
■ ■ boolean implies(java.security.Permission)
■ ■ java.security.PermissionCollection
 newPermissionCollection()
■ ■ String getPath()
■ ■ int getPort()
■ ■ String getProtocol()
■ ■ String getQuery()
■ ■ String getRef()
■ ■ String getUserInfo()
■ ■ int hashCode()
■ ■ URLConnection openConnection()
 throws java.io.IOException
■ ■ final java.io.InputStream openStream()
 throws java.io.IOException
■ ■ boolean sameFile(URL)
■ ■ protected void set(String,String,int,
 String,String)
■ ■ protected void set(String,String,int,
 String,String,String,String)
■ ■ static void
 setURLStreamHandlerFactory(URLStream
 HandlerFactory)
■ ■ String toExternalForm()
■ ■ String toString()

■ ■ java.util.Enumeration
 findResources(String) throws
 java.io.IOException
■ ■ protected
 java.security.PermissionCollection
 getPermissions(java.security.CodeSource
)
■ ■ URL[] getURLs()
■ ■ static URLClassLoader
 newInstance(URL[])
■ ■ static URLClassLoader
 newInstance(URL[],ClassLoader)

■ ■ String getHeaderField(String)
■ ■ long getHeaderFieldDate(String,long)
■ ■ int getHeaderFieldInt(String,int)
■ ■ String getHeaderFieldKey(int)
■ ■ long getIfModifiedSince()
■ ■ java.io.InputStream getInputStream()
 throws java.io.IOException
■ ■ long getLastModified()
■ ■ java.io.OutputStream getOutputStream()
 throws java.io.IOException
■ ■ java.security.Permission getPermission()
 throws java.io.IOException
■ ■ String getRequestProperty(String)
■ ■ URL getURL()
■ ■ boolean getUseCaches()
■ ■ protected static String
 guessContentTypeFromName(String)
■ ■ static String
 guessContentTypeFromStream(java.io.In
 putStream) throws java.io.IOException
■ ■ protected long ifModifiedSince
■ ■ void setAllowUserInteraction(boolean)

```

- **static void**  
setContentHandlerFactory(ContentHandlerFactory)
- **static void**  
setDefaultAllowUserInteraction(boolean)
- **void setDefaultUseCaches(boolean)**
- **void setDoInput(boolean)**
- **void setDoOutput(boolean)**
- **class URLDecoder**
- **URLDecoder()**
- **class URLEncoder**
- **static String encode(String)**
- **abstract class URLStreamHandler**
- **URLStreamHandler()**
- **protected boolean equals(URL,URL)**
- **protected int getDefaultPort()**
- **protected InetAddress**  
getHostAddress(URL)
- **protected int hashCode(URL)**
- **protected boolean hostsEqual(URL,URL)**
- **interface URLStreamHandlerFactory**
- **abstract URLStreamHandler**  
createURLStreamHandler(String)
- **static void**  
setFileNameMap(FileNameMap)
- **void setIfModifiedSince(long)**
- **void setRequestProperty(String,String)**
- **void setUseCaches(boolean)**
- **String toString()**
- **protected URL url**
- **protected boolean useCaches**
- **static String decode(String)**
- **abstract protected URLConnection**  
openConnection(URL) throws  
java.io.IOException
- **protected void parseURL(URL,String,int,  
int)**
- **protected boolean sameFile(URL,URL)**
- **protected void setURL(URL,String,String,  
int,String,String,String,String,String)**
- **protected String toExternalForm(URL)**

## 999.3.7

### java.security

- **package java.security**
- **final class AccessControlContext**
- **AccessControlContext(ProtectionDomain  
[])**
- **AccessControlContext(AccessControlCon  
text,DomainCombiner)**
- **class AccessControlException extends SecurityException**
- **AccessControlException(String)**
- **AccessControlException(String,  
Permission)**
- **final class AccessController**
- **static void checkPermission(Permission)  
throws AccessControlException**
- **static Object**  
doPrivileged(PrivilegedAction)
- **static Object**  
doPrivileged(PrivilegedAction,  
AccessControlContext)
- **class AlgorithmParameterGenerator**
- **protected**  
AlgorithmParameterGenerator(Algorithm  
ParameterGeneratorSpi,Provider,String)
- **final AlgorithmParameters**  
generateParameters()
- **final String getAlgorithm()**
- **static AlgorithmParameterGenerator**  
getInstance(String) throws  
NoSuchAlgorithmException
- **static AlgorithmParameterGenerator**  
getInstance(String,String) throws  
NoSuchAlgorithmException,  
NoSuchProviderException
- **abstract class AlgorithmParameterGeneratorSpi**
- **AlgorithmParameterGeneratorSpi()**
- **abstract protected AlgorithmParameters**  
engineGenerateParameters()
- **abstract protected void engineInit(int,  
SecureRandom)**
- **void checkPermission(Permission)  
throws AccessControlException**
- **boolean equals(Object)**
- **DomainCombiner getDomainCombiner()**
- **int hashCode()**
- **Permission getPermission()**
- **static Object**  
doPrivileged(PrivilegedExceptionAction)  
throws PrivilegedActionException
- **static Object**  
doPrivileged(PrivilegedExceptionAction,  
AccessControlContext) throws  
PrivilegedActionException
- **static AccessControlContext**  
getContext()
- **final Provider getProvider()**
- **final void init(int)**
- **final void init(int,SecureRandom)**
- **final void init(AlgorithmParameterSpec)  
throws  
InvalidAlgorithmParameterException**
- **final void init(AlgorithmParameterSpec,  
SecureRandom) throws  
InvalidAlgorithmParameterException**
- **abstract protected void**  
engineInit(AlgorithmParameterSpec,  
SecureRandom) throws  
InvalidAlgorithmParameterException

- **class AlgorithmParameters**
  - **protected**
    - AlgorithmParameters(AlgorithmParametersSpi, Provider, String)
  - **final String** getAlgorithm()
  - **final byte[]** getEncoded() throws java.io.IOException
  - **final byte[]** getEncoded(String) throws java.io.IOException
  - **static AlgorithmParameters** getInstance(String) throws NoSuchAlgorithmException
  - **static AlgorithmParameters** getInstance(String, String) throws NoSuchAlgorithmException, NoSuchProviderException
  - **abstract class AlgorithmParametersSpi**
  - **AlgorithmParametersSpi()**
  - **abstract protected byte[]** engineGetEncoded() throws java.io.IOException
  - **abstract protected byte[]** engineGetEncoded(String) throws java.io.IOException
  - **abstract protected** AlgorithmParameterSpec engineGetParameterSpec(Class) throws InvalidParameterSpecException
- **final class AllPermission extends Permission**
- **AllPermission()**
- **AllPermission(String, String)**
- **boolean** equals(Object)
- **String** getActions()
- **abstract class BasicPermission extends Permission implements java.io.Serializable**
- **BasicPermission(String)**
- **BasicPermission(String, String)**
- **boolean** equals(Object)
- **String** getActions()
- **interface Certificate**
- **abstract void** decode(java.io.InputStream) throws KeyException, java.io.IOException
- **abstract void** encode(java.io.OutputStream) throws KeyException, java.io.IOException
- **class CodeSource implements java.io.Serializable**
- **CodeSource(java.net.URL, Certificate[])**
- **boolean** equals(Object)
- **final Certificate[]** getCertificates()
- **final java.net.URL** getLocation()
- **class DigestException extends GeneralSecurityException**
- **DigestException()**
- **DigestException(String)**
- **class DigestInputStream extends java.io.FilterInputStream**
- **DigestInputStream(java.io.InputStream, MessageDigest)**
- **protected MessageDigest** digest
- **MessageDigest** getMessageDigest()
- **void** on(boolean)
- **class DigestOutputStream extends java.io.FilterOutputStream**
- **DigestOutputStream(java.io.OutputStream, MessageDigest)**
- **protected MessageDigest** digest
- **MessageDigest** getMessageDigest()
- **void** on(boolean)
- **interface DomainCombiner**
- **abstract ProtectionDomain[]** combine(ProtectionDomain[], ProtectionDomain[])
- **class GeneralSecurityException extends Exception**
- **GeneralSecurityException()**
- **GeneralSecurityException(String)**
- **final AlgorithmParameterSpec** getParameterSpec(Class) throws InvalidParameterSpecException
- **final Provider** getProvider()
- **final void** init(byte[]) throws java.io.IOException
- **final void** init(byte[], String) throws java.io.IOException
- **final void** init(AlgorithmParameterSpec) throws InvalidParameterSpecException
- **final String** toString()
- **abstract protected void** engineInit(byte[]) throws java.io.IOException
- **abstract protected void** engineInit(byte[], String) throws java.io.IOException
- **abstract protected void** engineInit(AlgorithmParameterSpec) throws InvalidParameterSpecException
- **abstract protected String** engineToString()
- **int** hashCode()
- **boolean** implies(Permission)
- **PermissionCollection** newPermissionCollection()
- **int** hashCode()
- **boolean** implies(Permission)
- **PermissionCollection** newPermissionCollection()
- **abstract String** getFormat()
- **abstract Principal** getGuarantor()
- **abstract Principal** getPrincipal()
- **abstract PublicKey** getPublicKey()
- **abstract String** toString(boolean)
- **int** hashCode()
- **boolean** implies(CodeSource)
- **String** toString()
- **int** read() throws java.io.IOException
- **int** read(byte[], int, int) throws java.io.IOException
- **void** setMessageDigest(MessageDigest)
- **String** toString()
- **void** setMessageDigest(MessageDigest)
- **String** toString()
- **void** write(byte[], int, int) throws java.io.IOException
- **void** write(int) throws java.io.IOException

- **interface Guard**
- **abstract void checkGuard(Object)**  
throws **SecurityException**
- **class GuardedObject implements java.io.Serializable**
- **GuardedObject(Object, Guard)** ■ **Object getObject()** throws **SecurityException**
- **abstract class Identity implements Principal, java.io.Serializable**
- **protected Identity()** □ **final IdentityScope getScope()**
- **Identity(String)** □ **int hashCode()**
- **Identity(String, IdentityScope)** throws **KeyManagementException** □ **protected boolean identityEquals(Identity)**
- **void addCertificate(Certificate)** throws **KeyManagementException** □ **void removeCertificate(Certificate)** throws **KeyManagementException**
- **Certificate[] certificates()** □ **void setInfo(String)**
- **final boolean equals(Object)** □ **void setPublicKey(PublicKey)** throws **KeyManagementException**
- **String getInfo()** □ **String toString()**
- **final String getName()** □ **String toString(boolean)**
- **PublicKey getPublicKey()**
- **abstract class IdentityScope extends Identity**
- **protected IdentityScope()** □ **static IdentityScope getSystemScope()**
- **IdentityScope(String)** □ **abstract java.util Enumeration identities()**
- **IdentityScope(String, IdentityScope)** throws **KeyManagementException** □ **abstract void removeIdentity(Identity)** throws **KeyManagementException**
- **abstract void addIdentity(Identity)** throws **KeyManagementException** □ **protected static void setSystemScope(IdentityScope)**
- **abstract Identity getIdentity(String)** □ **abstract int size()**
- **Identity getIdentity(Principal)** □ **String toString()**
- **abstract Identity getIdentity(PublicKey)**
- **class InvalidAlgorithmParameterException extends GeneralSecurityException**
- **InvalidAlgorithmParameterException()** □ **InvalidAlgorithmParameterException(String)**
- **class InvalidKeyException extends KeyException**
- **InvalidKeyException()** ■ **InvalidKeyException(String)**
- **class InvalidParameterException extends IllegalArgumentException**
- **InvalidParameterException()** ■ **InvalidParameterException(String)**
- **interface Key extends java.io.Serializable**
- **abstract String getAlgorithm()** ■ **abstract String getFormat()**
- **abstract byte[] getEncoded()** ■ **final static long serialVersionUID**
- **class KeyException extends GeneralSecurityException**
- **KeyException()** ■ **KeyException(String)**
- **class KeyFactory**
- **protected KeyFactory(KeyFactorySpi, Provider, String)** □ **static KeyFactory getInstance(String, String)** throws **NoSuchAlgorithmException**, **NoSuchProviderException**
- **final PrivateKey generatePrivate(KeySpec)** throws **InvalidKeySpecException** □ **final KeySpec getKeySpec(Key, Class)** throws **InvalidKeySpecException**
- **final PublicKey generatePublic(KeySpec)** throws **InvalidKeySpecException** □ **final Provider getProvider()**
- **final String getAlgorithm()** □ **final Key translateKey(Key)** throws **InvalidKeyException**
- **static KeyFactory getInstance(String)** throws **NoSuchAlgorithmException**
- **abstract class KeyFactorySpi**
- **KeyFactorySpi()** □ **abstract protected KeySpec engineGetKeySpec(Key, Class)** throws **InvalidKeySpecException**
- **abstract protected PrivateKey engineGeneratePrivate(KeySpec)** throws **InvalidKeySpecException** □ **abstract protected Key engineTranslateKey(Key)** throws **InvalidKeyException**
- **abstract protected PublicKey engineGeneratePublic(KeySpec)** throws **InvalidKeySpecException**
- **class KeyManagementException extends KeyException**
- **KeyManagementException()** ■ **KeyManagementException(String)**
- **final class KeyPair implements java.io.Serializable**
- **KeyPair(PublicKey, PrivateKey)** □ **PublicKey getPublic()**
- **PrivateKey getPrivate()**
- **abstract class KeyPairGenerator extends KeyPairGeneratorSpi**
- **protected KeyPairGenerator(String)** □ **static KeyPairGenerator getInstance(String)** throws **NoSuchAlgorithmException**
- **KeyPair generateKeyPair()**
- **final KeyPair genKeyPair()**
- **String getAlgorithm()**

- ■ **static** **KeyPairGenerator** **getInstance(String,String)** throws **NoSuchAlgorithmException**, **NoSuchProviderException**
- ■ **final** **Provider** **getProvider()**
- ■ **void** **initialize(int)**
- ■ **void** **initialize(int,SecureRandom)**
- ■ **abstract class** **KeyPairGeneratorSpi**
- ■ **KeyPairGeneratorSpi()**
- ■ **abstract** **KeyPair** **generateKeyPair()**
- ■ **abstract** **void** **initialize(int,SecureRandom)**
- ■ **class** **KeyStore**
- ■ **protected** **KeyStore(KeyStoreSpi,Provider,String)**
- ■ **final** **java.util.Enumeration** **aliases()** throws **KeyStoreException**
- ■ **final** **boolean** **containsAlias(String)** throws **KeyStoreException**
- ■ **final** **void** **deleteEntry(String)** throws **KeyStoreException**
- ■ **final** **Certificate** **getCertificate(String)** throws **KeyStoreException**
- ■ **final** **String** **getCertificateAlias(Certificate)** throws **KeyStoreException**
- ■ **final** **Certificate[]** **getCertificateChain(String)** throws **KeyStoreException**
- ■ **final** **java.util.Date** **getCreationDate(String)** throws **KeyStoreException**
- ■ **final** **static** **String** **getDefaultType()**
- ■ **static** **KeyStore** **getInstance(String)** throws **KeyStoreException**
- ■ **static** **KeyStore** **getInstance(String,String)** throws **KeyStoreException**, **NoSuchProviderException**
- ■ **class** **KeyStoreException** **extends** **GeneralSecurityException**
- ■ **KeyStoreException()**
- ■ **abstract class** **KeyStoreSpi**
- ■ **KeyStoreSpi()**
- ■ **abstract** **java.util.Enumeration** **engineAliases()**
- ■ **abstract** **boolean** **engineContainsAlias(String)**
- ■ **abstract** **void** **engineDeleteEntry(String)** throws **KeyStoreException**
- ■ **abstract** **Certificate** **engineGetCertificate(String)**
- ■ **abstract** **String** **engineGetCertificateAlias(Certificate)**
- ■ **abstract** **Certificate[]** **engineGetCertificateChain(String)**
- ■ **abstract** **java.util.Date** **engineGetCreationDate(String)**
- ■ **abstract** **Key** **engineGetKey(String,char[])** throws **NoSuchAlgorithmException**, **UnrecoverableKeyException**
- ■ **abstract** **boolean** **engineIsCertificateEntry(String)**
- ■ **abstract** **boolean** **engineIsKeyEntry(String)**
- ■ **abstract class** **MessageDigest** **extends** **MessageDigestSpi**
- ■ **protected** **MessageDigest(String)**
- ■ **Object** **clone()** throws **CloneNotSupportedException**
- ■ **byte[]** **digest()**
- ■ **byte[]** **digest(byte[])**
- ■ **void** **initialize(AlgorithmParameterSpec)** throws **InvalidAlgorithmParameterException**
- ■ **void** **initialize(AlgorithmParameterSpec,SecureRandom)** throws **InvalidAlgorithmParameterException**
- ■ **void** **initialize(AlgorithmParameterSpec,SecureRandom)** throws **InvalidAlgorithmParameterException**
- ■ **final** **Key** **getKey(String,char[])** throws **KeyStoreException**, **NoSuchAlgorithmException**, **UnrecoverableKeyException**
- ■ **final** **Provider** **getProvider()**
- ■ **final** **String** **getType()**
- ■ **final** **boolean** **isCertificateEntry(String)** throws **KeyStoreException**
- ■ **final** **boolean** **isKeyEntry(String)** throws **KeyStoreException**
- ■ **final** **void** **load(java.io.InputStream,char[])** throws **java.io.IOException**, **NoSuchAlgorithmException**, **CertificateException**
- ■ **final** **void** **setCertificateEntry(String,Certificate)** throws **KeyStoreException**
- ■ **final** **void** **setKeyEntry(String,byte[],Certificate[])** throws **KeyStoreException**
- ■ **final** **void** **setKeyEntry(String,Key,char[],Certificate[])** throws **KeyStoreException**
- ■ **final** **int** **size()** throws **KeyStoreException**
- ■ **final** **void** **store(java.io.OutputStream,char[])** throws **KeyStoreException**, **java.io.IOException**, **NoSuchAlgorithmException**, **CertificateException**
- ■ **KeyStoreException(String)**
- ■ **abstract** **void** **engineLoad(java.io.InputStream,char[])** throws **java.io.IOException**, **NoSuchAlgorithmException**, **CertificateException**
- ■ **abstract** **void** **engineSetCertificateEntry(String,Certificate)** throws **KeyStoreException**
- ■ **abstract** **void** **engineSetKeyEntry(String,byte[],Certificate[])** throws **KeyStoreException**
- ■ **abstract** **void** **engineSetKeyEntry(String,Key,char[],Certificate[])** throws **KeyStoreException**
- ■ **abstract** **int** **engineSize()**
- ■ **abstract** **void** **engineStore(java.io.OutputStream,char[])** throws **java.io.IOException**, **NoSuchAlgorithmException**, **CertificateException**
- ■ **int** **digest(byte[],int,int)** throws **DigestException**
- ■ **final** **String** **getAlgorithm()**
- ■ **final** **int** **getDigestLength()**
- ■ **static** **MessageDigest** **getInstance(String)** throws **NoSuchAlgorithmException**



- ❑ **static** MessageDigest getInstance(String, String) throws NoSuchAlgorithmException, NoSuchProviderException
  - ❑ **final** Provider getProvider()
  - ❑ **static** boolean isEqual(byte[], byte[])
  - ❑ **abstract class** MessageDigestSpi
  - ❑ MessageDigestSpi()
  - ❑ Object clone() throws CloneNotSupportedException
  - ❑ **abstract** protected byte[] engineDigest()
  - ❑ **protected** int engineDigest(byte[], int, int) throws DigestException
- ❑ **void** reset()
  - ❑ **String** toString()
  - ❑ **void** update(byte[])
  - ❑ **void** update(byte[], int, int)
  - ❑ **void** update(byte)
  - ❑ **protected** int engineGetDigestLength()
  - ❑ **abstract** **protected** **void** engineReset()
  - ❑ **abstract** **protected** **void** engineUpdate(byte[], int, int)
  - ❑ **abstract** **protected** **void** engineUpdate(byte)
- **class** NoSuchAlgorithmException extends GeneralSecurityException
  - NoSuchAlgorithmException()
  - NoSuchAlgorithmException(String)
- **class** NoSuchProviderException extends GeneralSecurityException
  - NoSuchProviderException()
  - NoSuchProviderException(String)
- **abstract class** Permission implements Guard, java.io.Serializable
  - Permission(String)
  - **void** checkGuard(Object) throws SecurityException
  - **abstract** **boolean** equals(Object)
  - **abstract** **String** getActions()
  - **final** **String** getName()
  - **abstract** **int** hashCode()
  - **abstract** **boolean** implies(Permission)
  - PermissionCollection
  - newPermissionCollection()
  - **String** toString()
- **abstract class** PermissionCollection implements java.io.Serializable
  - PermissionCollection()
  - **abstract** **void** add(Permission)
  - **abstract** **java.util.Enumeration** elements()
  - **abstract** **boolean** implies(Permission)
  - **boolean** isReadOnly()
  - **void** setReadOnly()
  - **String** toString()
- **final class** Permissions extends PermissionCollection implements java.io.Serializable
  - Permissions()
  - **void** add(Permission)
  - **java.util.Enumeration** elements()
  - **boolean** implies(Permission)
- **abstract class** Policy
  - Policy()
  - **abstract** **PermissionCollection** getPermissions(CodeSource)
  - **static** **Policy** getPolicy()
  - **abstract** **void** refresh()
  - **static** **void** setPolicy(Policy)
- **interface** Principal
  - **abstract** **boolean** equals(Object)
  - **abstract** **String** getName()
  - **abstract** **int** hashCode()
  - **abstract** **String** toString()
- ❑ **interface** PrivateKey extends Key
  - ❑ **final** **static** **long** serialVersionUID
- **interface** PrivilegedAction
  - **abstract** **Object** run()
- **class** PrivilegedActionException extends Exception
  - PrivilegedActionException(Exception)
  - Exception getException()
  - ❑ **void** printStackTrace()
  - **void** printStackTrace(java.io.PrintStream)
  - **void** printStackTrace(java.io.PrintWriter)
  - **String** toString()
- **interface** PrivilegedExceptionAction
  - **abstract** **Object** run() throws Exception
- **class** ProtectionDomain
  - ProtectionDomain(CodeSource, PermissionCollection)
  - **final** **CodeSource** getCodeSource()
  - **final** **PermissionCollection** getPermissions()
  - **boolean** implies(Permission)
  - **String** toString()
- **abstract class** Provider extends java.util.Properties
  - **protected** **Provider**(String, double, String)
  - **void** clear()
  - **java.util.Set** entrySet()
  - **String** getInfo()
  - **String** getName()
  - **double** getVersion()
  - **java.util.Set** keySet()
  - **void** load(java.io.InputStream) throws java.io.IOException
  - **Object** put(Object, Object)
  - **void** putAll(java.util.Map)
  - **Object** remove(Object)
  - **String** toString()
  - **java.util.Collection** values()
- ❑ **class** ProviderException extends RuntimeException
  - ❑ ProviderException()
  - ❑ ProviderException(String)
- **interface** PublicKey extends Key
  - **final** **static** **long** serialVersionUID
- **class** SecureClassLoader extends ClassLoader
  - **protected** **SecureClassLoader**()
  - **protected** **SecureClassLoader**(ClassLoader)
  - **final** **protected** **Class** defineClass(String, byte[], int, int, CodeSource)

- ■ protected PermissionCollection  
getPermissions(CodeSource)
- ■ **class SecureRandom extends java.util.Random**
- ■ SecureRandom()
- ■ SecureRandom(byte[])
- ■ protected  
SecureRandom(SecureRandomSpi,  
Provider)
- ■ byte[] generateSeed(int)
- ■ static SecureRandom getInstance(String)  
throws NoSuchAlgorithmException
- ■ **abstract class SecureRandomSpi implements java.io.Serializable**
- ■ SecureRandomSpi()
- ■ abstract protected byte[]  
engineGenerateSeed(int)
- ■ **final class Security**
- ■ static int addProvider(Provider)
- ■ static String getProperty(String)
- ■ static Provider getProvider(String)
- ■ static Provider[] getProviders()
- ■ static Provider[] getProviders(String)
- ■ **final class SecurityPermission extends BasicPermission**
- ■ SecurityPermission(String)
- ■ **abstract class Signature extends SignatureSpi**
- ■ protected Signature(String)
- ■ Object clone() throws  
CloneNotSupportedException
- ■ final String getAlgorithm()
- ■ static Signature getInstance(String)  
throws NoSuchAlgorithmException
- ■ static Signature getInstance(String,  
String) throws  
NoSuchAlgorithmException,  
NoSuchProviderException
- ■ final Provider getProvider()
- ■ final void initSign(PrivateKey) throws  
InvalidKeyException
- ■ final void initSign(PrivateKey,  
SecureRandom) throws  
InvalidKeyException
- ■ final void initVerify(Certificate) throws  
InvalidKeyException
- ■ final void initVerify(PublicKey) throws  
InvalidKeyException
- ■ **class SignatureException extends GeneralSecurityException**
- ■ SignatureException()
- ■ **abstract class SignatureSpi**
- ■ SignatureSpi()
- ■ protected SecureRandom appRandom
- ■ Object clone() throws  
CloneNotSupportedException
- ■ abstract protected void  
engineInitSign(PrivateKey) throws  
InvalidKeyException
- ■ protected void engineInitSign(PrivateKey,  
SecureRandom) throws  
InvalidKeyException
- ■ abstract protected void  
engineInitVerify(PublicKey) throws  
InvalidKeyException
- ■ protected void  
engineSetParameter(AlgorithmParameter  
Spec) throws  
InvalidAlgorithmParameterException
- ■ **final class SignedObject implements java.io.Serializable**
- ■ SignedObject(java.io.Serializable,  
PrivateKey,Signature) throws  
java.io.IOException, InvalidKeyException,  
SignatureException
- ■ static SecureRandom getInstance(String,  
String) throws  
NoSuchAlgorithmException,  
NoSuchProviderException
- ■ final Provider getProvider()
- ■ static byte[] getSeed(int)
- ■ final protected int next(int)
- ■ void nextBytes(byte[])
- ■ void setSeed(byte[])
- ■ void setSeed(long)
- ■ abstract protected void  
engineNextBytes(byte[])
- ■ abstract protected void  
engineSetSeed(byte[])
- ■ static Provider[]  
getProviders(java.util.Map)
- ■ static int insertProviderAt(Provider,int)
- ■ static void removeProvider(String)
- ■ static void setProperty(String,String)
- ■ SecurityPermission(String,String)
- ■ final void  
setParameter(AlgorithmParameterSpec)  
throws  
InvalidAlgorithmParameterException
- ■ final protected static int SIGN
- ■ final byte[] sign() throws  
SignatureException
- ■ final int sign(byte[],int,int) throws  
SignatureException
- ■ protected int state
- ■ String toString()
- ■ final protected static int UNINITIALIZED
- ■ final void update(byte[]) throws  
SignatureException
- ■ final void update(byte[],int,int) throws  
SignatureException
- ■ final void update(byte) throws  
SignatureException
- ■ final protected static int VERIFY
- ■ final boolean verify(byte[]) throws  
SignatureException
- ■ abstract protected byte[] engineSign()  
throws SignatureException
- ■ protected int engineSign(byte[],int,int)  
throws SignatureException
- ■ abstract protected void  
engineUpdate(byte[],int,int) throws  
SignatureException
- ■ abstract protected void  
engineUpdate(byte) throws  
SignatureException
- ■ abstract protected boolean  
engineVerify(byte[]) throws  
SignatureException

- ❑ `String getAlgorithm()`
- ❑ `Object getObject()` throws `java.io.IOException`, `ClassNotFoundException`
- ❑ **abstract class `Signer` extends `Identity`**
- ❑ `protected Signer()`
- ❑ `Signer(String)`
- ❑ `Signer(String, IdentityScope)` throws `KeyManagementException`
- ❑ **class `UnrecoverableKeyException` extends `GeneralSecurityException`**
- ❑ `UnrecoverableKeyException()`
- ❑ **final class `UnresolvedPermission` extends `Permission` implements `java.io.Serializable`**
- ❑ `UnresolvedPermission(String, String, String, Certificate[])`
- ❑ `boolean equals(Object)`
- ❑ `String getActions()`
- ❑ `int hashCode()`
- ❑ `byte[] getSignature()`
- ❑ `boolean verify(PublicKey, Signature)` throws `InvalidKeyException`, `SignatureException`
- ❑ `PrivateKey getPrivateKey()`
- ❑ `final void setKeyPair(KeyPair)` throws `InvalidParameterException`, `KeyException`
- ❑ `String toString()`
- ❑ `UnrecoverableKeyException(String)`
- ❑ `boolean implies(Permission)`
- ❑ `PermissionCollection newPermissionCollection()`
- ❑ `String toString()`

### 999.3.8

#### java.security.acl

- ❑ **package `java.security.acl`**
- ❑ **interface `Acl` extends `Owner`**
- ❑ `abstract boolean addEntry(java.security.Principal, AclEntry)` throws `NotOwnerException`
- ❑ `abstract boolean checkPermission(java.security.Principal, Permission)`
- ❑ `abstract java.util Enumeration entries()`
- ❑ `abstract String getName()`
- ❑ **interface `AclEntry` extends `Cloneable`**
- ❑ `abstract boolean addPermission(Permission)`
- ❑ `abstract boolean checkPermission(Permission)`
- ❑ `abstract Object clone()`
- ❑ `abstract java.security.Principal getPrincipal()`
- ❑ `abstract boolean isNegative()`
- ❑ **class `AclNotFoundException` extends `Exception`**
- ❑ `AclNotFoundException()`
- ❑ **interface `Group` extends `java.security.Principal`**
- ❑ `abstract boolean addMember(java.security.Principal)`
- ❑ `abstract boolean isMember(java.security.Principal)`
- ❑ **class `LastOwnerException` extends `Exception`**
- ❑ `LastOwnerException()`
- ❑ **class `NotOwnerException` extends `Exception`**
- ❑ `NotOwnerException()`
- ❑ **interface `Owner`**
- ❑ `abstract boolean addOwner(java.security.Principal, java.security.Principal)` throws `NotOwnerException`
- ❑ `abstract boolean deleteOwner(java.security.Principal, java.security.Principal)` throws `NotOwnerException`, `LastOwnerException`
- ❑ `abstract boolean isOwner(java.security.Principal)`
- ❑ `abstract boolean equals(Object)`
- ❑ `abstract String toString()`
- ❑ `abstract java.util Enumeration getPermissions(java.security.Principal)`
- ❑ `abstract boolean removeEntry(java.security.Principal, AclEntry)` throws `NotOwnerException`
- ❑ `abstract void setName(java.security.Principal, String)` throws `NotOwnerException`
- ❑ `abstract String toString()`
- ❑ `abstract java.util Enumeration permissions()`
- ❑ `abstract boolean removePermission(Permission)`
- ❑ `abstract void setNegativePermissions()`
- ❑ `abstract boolean setPrincipal(java.security.Principal)`
- ❑ `abstract String toString()`
- ❑ `abstract java.util Enumeration members()`
- ❑ `abstract boolean removeMember(java.security.Principal)`
- ❑ `abstract boolean deleteOwner(java.security.Principal, java.security.Principal)` throws `NotOwnerException`, `LastOwnerException`
- ❑ `abstract boolean isOwner(java.security.Principal)`
- ❑ `abstract String toString()`

### 999.3.9

#### java.security.cert

- ❑ **package `java.security.cert`**
- ❑ **abstract class `Certificate` implements `java.io.Serializable`**
- ❑ `protected Certificate(String)`
- ❑ `boolean equals(Object)`
- ❑ `abstract byte[] getEncoded()` throws `CertificateEncodingException`
- ❑ `abstract java.security.PublicKey getPublicKey()`
- ❑ `final String getType()`
- ❑ `int hashCode()`
- ❑ `abstract String toString()`

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>■ ■ abstract void<br/>verify(java.security.PublicKey) throws<br/>CertificateException,<br/>java.security.NoSuchAlgorithmException,<br/>java.security.InvalidKeyException,<br/>java.security.NoSuchProviderException,<br/>java.security.SignatureException</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <ul style="list-style-type: none"> <li>■ ■ abstract void<br/>verify(java.security.PublicKey,String)<br/>throws CertificateException,<br/>java.security.NoSuchAlgorithmException,<br/>java.security.InvalidKeyException,<br/>java.security.NoSuchProviderException,<br/>java.security.SignatureException</li> <li>■ ■ protected Object writeReplace() throws<br/>java.io.ObjectStreamException</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li>■ ■ class Certificate.CertificateRep implements java.io.Serializable</li> <li>■ ■ protected<br/>Certificate.CertificateRep(String,byte[])</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <ul style="list-style-type: none"> <li>■ ■ protected Object readResolve() throws<br/>java.io.ObjectStreamException</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>■ ■ class CertificateEncodingException extends CertificateException</li> <li>■ ■ CertificateEncodingException()</li> <li>■ ■ class CertificateException extends java.security.GeneralSecurityException</li> <li>■ ■ CertificateException()</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>■ ■ CertificateEncodingException(String)</li> <li>■ ■ CertificateException(String)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <ul style="list-style-type: none"> <li>□ ■ class CertificateExpiredException extends CertificateException</li> <li>□ ■ CertificateExpiredException()</li> <li>□ ■ class CertificateFactory</li> <li>□ ■ protected<br/>CertificateFactory(CertificateFactorySpi,<br/>java.security.Provider,String)</li> <li>□ ■ final Certificate<br/>generateCertificate(java.io.InputStream)<br/>throws CertificateException</li> <li>□ ■ final java.util.Collection<br/>generateCertificates(java.io.InputStream)<br/>throws CertificateException</li> <li>□ ■ final CRL<br/>generateCRL(java.io.InputStream)<br/>throws CRLException</li> <li>□ ■ abstract class CertificateFactorySpi</li> <li>□ ■ CertificateFactorySpi()</li> <li>□ ■ abstract Certificate<br/>engineGenerateCertificate(java.io.InputS<br/>tream) throws CertificateException</li> <li>□ ■ abstract java.util.Collection<br/>engineGenerateCertificates(java.io.Input<br/>Stream) throws CertificateException</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>□ ■ CertificateExpiredException(String)</li> <li>□ ■ final java.util.Collection<br/>generateCRLs(java.io.InputStream)<br/>throws CRLException</li> <li>□ ■ final static CertificateFactory<br/>getInstance(String) throws<br/>CertificateException</li> <li>□ ■ final static CertificateFactory<br/>getInstance(String,String) throws<br/>CertificateException,<br/>java.security.NoSuchProviderException</li> <li>□ ■ final java.security.Provider getProvider()</li> <li>□ ■ final String getType()</li> <li>□ ■ abstract CRL<br/>engineGenerateCRL(java.io.InputStream)<br/>throws CRLException</li> <li>□ ■ abstract java.util.Collection<br/>engineGenerateCRLs(java.io.InputStream<br/>) throws CRLException</li> </ul>                                                                                                                                                                                                                                                                   |
| <ul style="list-style-type: none"> <li>□ ■ class CertificateNotYetValidException extends CertificateException</li> <li>□ ■ CertificateNotYetValidException()</li> <li>□ ■ class CertificateParsingException extends CertificateException</li> <li>□ ■ CertificateParsingException()</li> <li>□ ■ abstract class CRL</li> <li>□ ■ protected CRL(String)</li> <li>□ ■ final String getType()</li> <li>□ ■ class CRLException extends java.security.GeneralSecurityException</li> <li>□ ■ CRLException()</li> <li>□ ■ abstract class X509Certificate extends Certificate implements X509Extension</li> <li>□ ■ protected X509Certificate()</li> <li>□ ■ abstract void checkValidity() throws<br/>CertificateExpiredException,<br/>CertificateNotYetValidException</li> <li>□ ■ abstract void<br/>checkValidity(java.util.Date) throws<br/>CertificateExpiredException,<br/>CertificateNotYetValidException</li> <li>□ ■ abstract int getBasicConstraints()</li> <li>□ ■ abstract java.util.Set<br/>getCriticalExtensionOIDs()</li> <li>□ ■ abstract byte[] getExtensionValue(String)</li> <li>□ ■ abstract java.security.Principal<br/>getIssuerDN()</li> <li>□ ■ abstract boolean[] getIssuerUniqueID()</li> <li>□ ■ abstract boolean[] getKeyUsage()</li> <li>□ ■ abstract java.util.Set<br/>getNonCriticalExtensionOIDs()</li> <li>□ ■ abstract class X509CRL extends CRL implements X509Extension</li> <li>□ ■ protected X509CRL()</li> <li>□ ■ boolean equals(Object)</li> </ul> | <ul style="list-style-type: none"> <li>□ ■ CertificateNotYetValidException(String)</li> <li>□ ■ CertificateParsingException(String)</li> <li>□ ■ abstract boolean isRevoked(Certificate)</li> <li>□ ■ abstract String toString()</li> <li>□ ■ CRLException(String)</li> <li>□ ■ abstract java.util.Date getNotAfter()</li> <li>□ ■ abstract java.util.Date getNotBefore()</li> <li>□ ■ abstract java.math.BigInteger<br/>getSerialNumber()</li> <li>□ ■ abstract String getSigAlgName()</li> <li>□ ■ abstract String getSigAlgOID()</li> <li>□ ■ abstract byte[] getSigAlgParams()</li> <li>□ ■ abstract byte[] getSignature()</li> <li>□ ■ abstract java.security.Principal<br/>getSubjectDN()</li> <li>□ ■ abstract boolean[] getSubjectUniqueID()</li> <li>□ ■ abstract byte[] getTBSCertificate()<br/>throws CertificateEncodingException</li> <li>□ ■ abstract int getVersion()</li> <li>□ ■ abstract boolean<br/>hasUnsupportedCriticalExtension()</li> <li>□ ■ abstract java.util.Set<br/>getCriticalExtensionOIDs()</li> </ul> |

- ■ abstract byte[] getEncoded() throws  
CRLException
- ■ abstract byte[] getExtensionValue(String)
- ■ abstract java.security.Principal  
getIssuerDN()
- ■ abstract java.util.Date getNextUpdate()
- ■ abstract java.util.Set  
getNonCriticalExtensionOIDs()
- ■ abstract X509CRLEntry  
getRevokedCertificate(java.math.BigInteg  
er)
- ■ abstract java.util.Set  
getRevokedCertificates()
- ■ abstract String getSigAlgName()
- ■ abstract String getSigAlgOID()
- ■ abstract byte[] getSigAlgParams()
- ■ abstract byte[] getSignature()
- ■ abstract byte[] getTBSCertList() throws  
CRLException
- ■ **abstract class X509CRLEntry implements X509Extension**
- ■ X509CRLEntry()
- ■ boolean equals(Object)
- ■ abstract java.util.Set  
getCriticalExtensionOIDs()
- ■ abstract byte[] getEncoded() throws  
CRLException
- ■ abstract byte[] getExtensionValue(String)
- ■ abstract java.util.Set  
getNonCriticalExtensionOIDs()
- ■ **interface X509Extension**
- ■ abstract java.util.Set  
getCriticalExtensionOIDs()
- ■ abstract byte[] getExtensionValue(String)
- ■ abstract java.util.Date getThisUpdate()
- ■ abstract int getVersion()
- ■ int hashCode()
- ■ abstract boolean  
hasUnsupportedCriticalExtension()
- ■ abstract void  
verify(java.security.PublicKey) throws  
CRLException,  
java.security.NoSuchAlgorithmException,  
java.security.InvalidKeyException,  
java.security.NoSuchProviderException,  
java.security.SignatureException
- ■ abstract void  
verify(java.security.PublicKey,String)  
throws CRLException,  
java.security.NoSuchAlgorithmException,  
java.security.InvalidKeyException,  
java.security.NoSuchProviderException,  
java.security.SignatureException
- ■ abstract java.util.Date  
getRevocationDate()
- ■ abstract java.math.BigInteger  
getSerialNumber()
- ■ abstract boolean hasExtensions()
- ■ int hashCode()
- ■ abstract boolean  
hasUnsupportedCriticalExtension()
- ■ abstract String toString()
- ■ abstract java.util.Set  
getNonCriticalExtensionOIDs()
- ■ abstract boolean  
hasUnsupportedCriticalExtension()

## 999.3.10

### java.security.interfaces

- ■ **package java.security.interfaces**
- ■ **interface DSAKey**
- ■ abstract DSAParams getParams()
- ■ **interface DSAKeyPairGenerator**
- ■ abstract void initialize(int,boolean,  
java.security.SecureRandom) throws  
java.security.InvalidParameterException
- ■ abstract void initialize(DSAParams,  
java.security.SecureRandom) throws  
java.security.InvalidParameterException
- ■ **interface DSAParams**
- ■ abstract java.math.BigInteger getG()
- ■ abstract java.math.BigInteger getP()
- ■ **interface DSAPrivateKey extends DSAKey , java.security.PrivateKey**
- ■ abstract java.math.BigInteger getX()
- ■ **interface DSAPublicKey extends DSAKey , java.security.PublicKey**
- ■ abstract java.math.BigInteger getY()
- ■ **interface RSAKey**
- ■ abstract java.math.BigInteger  
getModulus()
- ■ **interface RSAPrivateCrtKey extends RSAPrivateKey**
- ■ abstract java.math.BigInteger  
getCrtCoefficient()
- ■ abstract java.math.BigInteger  
getPrimeExponentP()
- ■ abstract java.math.BigInteger  
getPrimeExponentQ()
- ■ **interface RSAPrivateKey extends java.security.PrivateKey , RSAKey**
- ■ abstract java.math.BigInteger  
getPrivateExponent()
- ■ **interface RSAPublicKey extends java.security.PublicKey , RSAKey**
- ■ abstract java.math.BigInteger  
getPublicExponent()
- ■ abstract java.math.BigInteger getQ()
- ■ final static long serialVersionUID
- ■ final static long serialVersionUID
- ■ abstract java.math.BigInteger getPrimeP()
- ■ abstract java.math.BigInteger  
getPrimeQ()
- ■ abstract java.math.BigInteger  
getPublicExponent()

## 999.3.11

## java.security.spec

- **package** java.security.spec
- **interface** AlgorithmParameterSpec
- **class** DSAPrivateKeySpec implements KeySpec
  - DSAPrivateKeySpec(java.math.BigInteger, java.math.BigInteger)
  - java.math.BigInteger getG()
  - java.math.BigInteger getP()
  - java.math.BigInteger getQ()
  - java.math.BigInteger getX()
- **class** DSAPublicKeySpec implements KeySpec
  - DSAPublicKeySpec(java.math.BigInteger, java.math.BigInteger)
  - java.math.BigInteger getG()
  - java.math.BigInteger getP()
  - java.math.BigInteger getQ()
  - java.math.BigInteger getY()
- **abstract class** EncodedKeySpec implements KeySpec
  - EncodedKeySpec(byte[])
  - byte[] getEncoded()
  - abstract String getFormat()
- **class** InvalidKeySpecException extends java.security.GeneralSecurityException
  - InvalidKeySpecException()
  - InvalidKeySpecException(String)
- **class** InvalidParameterSpecException extends java.security.GeneralSecurityException
  - InvalidParameterSpecException()
  - InvalidParameterSpecException(String)
- **interface** KeySpec
- **class** PKCS8EncodedKeySpec extends EncodedKeySpec
  - PKCS8EncodedKeySpec(byte[])
  - byte[] getEncoded()
  - final String getFormat()
- **class** RSAKeyGenParameterSpec implements AlgorithmParameterSpec
  - RSAKeyGenParameterSpec(int, java.math.BigInteger)
  - final static java.math.BigInteger F4
  - int getKeySize()
  - java.math.BigInteger getPublicExponent()
- **class** RSAPrivateCrtKeySpec extends RSAPrivateKeySpec
  - RSAPrivateCrtKeySpec(java.math.BigInteger, java.math.BigInteger, java.math.BigInteger, java.math.BigInteger, java.math.BigInteger, java.math.BigInteger)
  - java.math.BigInteger getModulus()
  - java.math.BigInteger getPrimeExponentP()
  - java.math.BigInteger getPrimeExponentQ()
  - java.math.BigInteger getPrimeP()
  - java.math.BigInteger getPrimeQ()
  - java.math.BigInteger getPublicExponent()
  - java.math.BigInteger getPrivateExponent()
- **class** RSAPrivateKeySpec implements KeySpec
  - RSAPrivateKeySpec(java.math.BigInteger, java.math.BigInteger)
  - java.math.BigInteger getModulus()
  - java.math.BigInteger getPublicExponent()
- **class** RSAPublicKeySpec implements KeySpec
  - RSAPublicKeySpec(java.math.BigInteger, java.math.BigInteger)
  - java.math.BigInteger getModulus()
  - java.math.BigInteger getPublicExponent()
- **class** X509EncodedKeySpec extends EncodedKeySpec
  - X509EncodedKeySpec(byte[])
  - byte[] getEncoded()
  - final String getFormat()

## 999.3.12

## java.text

- **package** java.text
- **class** Annotation
  - Annotation(Object)
  - Object getValue()
  - String toString()
- **interface** AttributedCharacterIterator extends CharacterIterator
- **abstract** java.util.Set
  - getAllAttributeKeys()
  - abstract int getRunLimit(AttributedCharacterIterator.Attribute)
  - abstract java.util.Map getAttributes()
  - abstract int getRunStart(AttributedCharacterIterator.Attribute)
- **abstract** Object
  - getAttribute(AttributedCharacterIterator.Attribute)
  - abstract int getRunLimit(java.util.Set)
  - abstract int getRunStart()
  - abstract int getRunStart(AttributedCharacterIterator.Attribute)

- **class AttributedCharacterIterator.Attribute implements java.io.Serializable**
  - protected
    - AttributedCharacterIterator.Attribute(String)
  - final boolean equals(Object)
  - protected String getName()
  - final int hashCode()
  - final static
    - AttributedCharacterIterator.Attribute INPUT\_METHOD\_SEGMENT
  - **class AttributedString**
  - AttributedString(String)
  - AttributedString(String, java.util.Map)
  - - AttributedString(AttributedCharacterIterator)
  - - AttributedString(AttributedCharacterIterator, int, int)
  - - AttributedString(AttributedCharacterIterator, int, int, AttributedCharacterIterator.Attribute[])
- final static
    - AttributedCharacterIterator.Attribute LANGUAGE
  - final static
    - AttributedCharacterIterator.Attribute READING
  - protected Object readResolve() throws java.io.InvalidObjectException
  - String toString()
- void
    - addAttribute(AttributedCharacterIterator.Attribute, Object)
  - void
    - addAttribute(AttributedCharacterIterator.Attribute, Object, int, int)
  - void addAttributes(java.util.Map, int, int)
  - AttributedCharacterIterator getIterator()
  - AttributedCharacterIterator getIterator(AttributedCharacterIterator.Attribute[])
  - AttributedCharacterIterator getIterator(AttributedCharacterIterator.Attribute[], int, int)
- **abstract class BreakIterator implements Cloneable**
  - protected BreakIterator()
  - Object clone()
  - abstract int current()
  - final static int DONE
  - abstract int first()
  - abstract int following(int)
  - static java.util.Locale[]
    - getAvailableLocales()
  - static BreakIterator
    - getCharacterInstance()
  - static BreakIterator
    - getCharacterInstance(java.util.Locale)
  - static BreakIterator getLineInstance()
  - static BreakIterator
    - getLineInstance(java.util.Locale)
  - static BreakIterator
    - getSentenceInstance()
  - static BreakIterator
    - getSentenceInstance(java.util.Locale)
  - abstract CharacterIterator getText()
  - static BreakIterator
    - getWordInstance()
  - static BreakIterator
    - getWordInstance(java.util.Locale)
  - boolean isBoundary(int)
  - abstract int last()
  - abstract int next()
  - abstract int next(int)
  - int preceding(int)
  - abstract int previous()
  - void setText(String)
  - abstract void setText(CharacterIterator)
- **interface CharacterIterator extends Cloneable**
  - abstract Object clone()
  - abstract char current()
  - final static char DONE
  - abstract char first()
  - abstract int getBeginIndex()
  - abstract int getEndIndex()
  - abstract int getIndex()
  - abstract char last()
  - abstract char next()
  - abstract char previous()
  - abstract char setIndex(int)
- **class ChoiceFormat extends NumberFormat**
  - ChoiceFormat(double[], String[])
  - ChoiceFormat(String)
  - void applyPattern(String)
  - Object clone()
  - boolean equals(Object)
  - StringBuffer format(double, StringBuffer, FieldPosition)
  - StringBuffer format(long, StringBuffer, FieldPosition)
  - Object[] getFormats()
  - final class CollationElementIterator
  - int getMaxExpansion(int)
  - int getOffset()
  - int next()
  - final static int NULLORDER
  - int previous()
  - final static int primaryOrder(int)
  - final class CollationKey implements Comparable
  - int compareTo(Object)
  - int compareTo(CollationKey)
  - boolean equals(Object)
- double[] getLimits()
  - int hashCode()
  - final static double nextDouble(double)
  - static double nextDouble(double, boolean)
  - Number parse(String, ParsePosition)
  - final static double previousDouble(double)
  - void setChoices(double[], String[])
  - String toPattern()
  - void reset()
  - final static short secondaryOrder(int)
  - void setOffset(int)
  - void setText(String)
  - void setText(CharacterIterator)
  - final static short tertiaryOrder(int)
  - String getSourceString()
  - int hashCode()
  - byte[] toByteArray()

- ■ **abstract class Collator implements java.util.Comparator , Cloneable**
- ■ protected Collator()
- ■ final static int CANONICAL\_DECOMPOSITION
- ■ Object clone()
- ■ int compare(Object, Object)
- ■ abstract int compare(String, String)
- ■ boolean equals(Object)
- ■ boolean equals(String, String)
- ■ final static int FULL\_DECOMPOSITION
- ■ static java.util.Locale[] getAvailableLocales()
- ■ abstract CollationKey getCollationKey(String)
- ■ **abstract class DateFormat extends Format**
- ■ protected DateFormat()
- ■ final static int AM\_PM\_FIELD
- ■ protected java.util.Calendar calendar
- ■ Object clone()
- ■ final static int DATE\_FIELD
- ■ final static int DAY\_OF\_WEEK\_FIELD
- ■ final static int DAY\_OF\_WEEK\_IN\_MONTH\_FIELD
- ■ final static int DAY\_OF\_YEAR\_FIELD
- ■ final static int DEFAULT
- ■ boolean equals(Object)
- ■ final static int ERA\_FIELD
- ■ final StringBuffer format(Object, StringBuffer, FieldPosition)
- ■ final String format(java.util.Date)
- ■ abstract StringBuffer format(java.util.Date, StringBuffer, FieldPosition)
- ■ final static int FULL
- ■ static java.util.Locale[] getAvailableLocales()
- ■ java.util.Calendar getCalendar()
- ■ final static DateFormat getDateTimeInstance()
- ■ final static DateFormat getDateTimeInstance(int)
- ■ final static DateFormat getDateTimeInstance(int, java.util.Locale)
- ■ final static DateFormat getDateTimeInstance(int, java.util.Locale)
- ■ final static DateFormat getDateTimeInstance(int, int, java.util.Locale)
- ■ final static DateFormat getInstance()
- ■ **class DateFormatSymbols implements java.io.Serializable , Cloneable**
- ■ DateFormatSymbols()
- ■ DateFormatSymbols(java.util.Locale)
- ■ Object clone()
- ■ boolean equals(Object)
- ■ String[] getAmPmStrings()
- ■ String[] getEras()
- ■ String getLocalPatternChars()
- ■ String[] getMonths()
- ■ String[] getShortMonths()
- ■ String[] getShortWeekdays()
- ■ String[] getWeekdays()
- ■ **class DecimalFormat extends NumberFormat**
- ■ DecimalFormat()
- ■ DecimalFormat(String)
- ■ DecimalFormat(String, DecimalFormatSymbols)
- ■ void applyLocalizedPattern(String)
- ■ void applyPattern(String)
- ■ Object clone()
- ■ boolean equals(Object)
- ■ int getDecomposition()
- ■ static Collator getInstance()
- ■ static Collator getInstance(java.util.Locale)
- ■ int getStrength()
- ■ abstract int hashCode()
- ■ final static int IDENTICAL
- ■ final static int NO\_DECOMPOSITION
- ■ final static int PRIMARY
- ■ final static int SECONDARY
- ■ void setDecomposition(int)
- ■ void setStrength(int)
- ■ final static int TERTIARY
- ■ NumberFormat getNumberFormat()
- ■ final static DateFormat getDateTimeInstance()
- ■ final static DateFormat getDateTimeInstance(int)
- ■ final static DateFormat getDateTimeInstance(int, java.util.Locale)
- ■ java.util.TimeZone getTimeZone()
- ■ int hashCode()
- ■ final static int HOUR0\_FIELD
- ■ final static int HOUR1\_FIELD
- ■ final static int HOUR\_OF\_DAY0\_FIELD
- ■ final static int HOUR\_OF\_DAY1\_FIELD
- ■ boolean isLenient()
- ■ final static int LONG
- ■ final static int MEDIUM
- ■ final static int MILLISECOND\_FIELD
- ■ final static int MINUTE\_FIELD
- ■ final static int MONTH\_FIELD
- ■ protected NumberFormat numberFormat
- ■ java.util.Date parse(String) throws ParseException
- ■ abstract java.util.Date parse(String, ParsePosition)
- ■ Object parseObject(String, ParsePosition)
- ■ final static int SECOND\_FIELD
- ■ void setCalendar(java.util.Calendar)
- ■ void setLenient(boolean)
- ■ void setNumberFormat(NumberFormat)
- ■ void setTimeZone(java.util.TimeZone)
- ■ final static int SHORT
- ■ final static int TIMEZONE\_FIELD
- ■ final static int WEEK\_OF\_MONTH\_FIELD
- ■ final static int WEEK\_OF\_YEAR\_FIELD
- ■ final static int YEAR\_FIELD
- ■ String[][] getZoneStrings()
- ■ int hashCode()
- ■ void setAmPmStrings(String[])
- ■ void setEras(String[])
- ■ void setLocalPatternChars(String)
- ■ void setMonths(String[])
- ■ void setShortMonths(String[])
- ■ void setShortWeekdays(String[])
- ■ void setWeekdays(String[])
- ■ void setZoneStrings(String[][])
- ■ StringBuffer format(double, StringBuffer, FieldPosition)
- ■ StringBuffer format(long, StringBuffer, FieldPosition)
- ■ DecimalFormatSymbols getDecimalFormatSymbols()
- ■ int getGroupingSize()
- ■ int getMultiplier()



- `String getNegativePrefix()`
- `String getNegativeSuffix()`
- `String getPositivePrefix()`
- `String getPositiveSuffix()`
- `int hashCode()`
- `boolean isDecimalSeparatorAlwaysShown()`
- `Number parse(String, ParsePosition)`
- `void setDecimalFormatSymbols(DecimalFormatSymbols)`
- `void setDecimalSeparatorAlwaysShown(boolean)`
- **final class DecimalFormatSymbols implements Cloneable, java.io.Serializable**
- `DecimalFormatSymbols()`
- `DecimalFormatSymbols(java.util.Locale)`
- `Object clone()`
- `boolean equals(Object)`
- `String getCurrencySymbol()`
- `char getDecimalSeparator()`
- `char getDigit()`
- `char getGroupingSeparator()`
- `String getInfinity()`
- `String getInternationalCurrencySymbol()`
- `char getMinusSign()`
- `char getMonetaryDecimalSeparator()`
- `String getNaN()`
- `char getPatternSeparator()`
- `char getPercent()`
- `char getPerMill()`
- **class FieldPosition**
- `FieldPosition(int)`
- `boolean equals(Object)`
- `int getBeginIndex()`
- `int getEndIndex()`
- `int getField()`
- **abstract class Format implements java.io.Serializable, Cloneable**
- `Format()`
- `Object clone()`
- `final String format(Object)`
- `abstract StringBuffer format(Object, StringBuffer, FieldPosition)`
- **class MessageFormat extends Format**
- `MessageFormat(String)`
- `void applyPattern(String)`
- `Object clone()`
- `boolean equals(Object)`
- `final StringBuffer format(Object[], StringBuffer, FieldPosition)`
- `final StringBuffer format(Object, StringBuffer, FieldPosition)`
- `static String format(String, Object[])`
- `Format[] getFormats()`
- **abstract class NumberFormat extends Format**
- `NumberFormat()`
- `Object clone()`
- `boolean equals(Object)`
- `final String format(double)`
- `abstract StringBuffer format(double, StringBuffer, FieldPosition)`
- `final String format(long)`
- `abstract StringBuffer format(long, StringBuffer, FieldPosition)`
- `final StringBuffer format(Object, StringBuffer, FieldPosition)`
- `final static int FRACTION_FIELD`
- `static java.util.Locale[] getAvailableLocales()`
- `final static NumberFormat getCurrencyInstance()`
- `void setGroupingSize(int)`
- `void setMaximumFractionDigits(int)`
- `void setMaximumIntegerDigits(int)`
- `void setMinimumFractionDigits(int)`
- `void setMinimumIntegerDigits(int)`
- `void setMultiplier(int)`
- `void setNegativePrefix(String)`
- `void setNegativeSuffix(String)`
- `void setPositivePrefix(String)`
- `void setPositiveSuffix(String)`
- `String toLocalizedPattern()`
- `String toPattern()`
- `char getZeroDigit()`
- `int hashCode()`
- `void setCurrencySymbol(String)`
- `void setDecimalSeparator(char)`
- `void setDigit(char)`
- `void setGroupingSeparator(char)`
- `void setInfinity(String)`
- `void setInternationalCurrencySymbol(String)`
- `void setMinusSign(char)`
- `void setMonetaryDecimalSeparator(char)`
- `void setNaN(String)`
- `void setPatternSeparator(char)`
- `void setPercent(char)`
- `void setPerMill(char)`
- `void setZeroDigit(char)`
- `int hashCode()`
- `void setBeginIndex(int)`
- `void setEndIndex(int)`
- `String toString()`
- `Object parseObject(String) throws ParseException`
- `abstract Object parseObject(String, ParsePosition)`
- `java.util.Locale getLocale()`
- `int hashCode()`
- `Object[] parse(String) throws ParseException`
- `Object[] parse(String, ParsePosition)`
- `Object parseObject(String, ParsePosition)`
- `void setFormat(int, Format)`
- `void setFormats(Format[])`
- `void setLocale(java.util.Locale)`
- `String toPattern()`
- `static NumberFormat getCurrencyInstance(java.util.Locale)`
- `final static NumberFormat getInstance()`
- `static NumberFormat getInstance(java.util.Locale)`
- `int getMaximumFractionDigits()`
- `int getMaximumIntegerDigits()`
- `int getMinimumFractionDigits()`
- `int getMinimumIntegerDigits()`
- `final static NumberFormat getNumberInstance()`
- `static NumberFormat getNumberInstance(java.util.Locale)`
- `final static NumberFormat getPercentInstance()`

- **static** NumberFormat
  - **getPercentInstance**(java.util.Locale)
  - **int** hashCode()
  - **final static int** INTEGER\_FIELD
  - **boolean** isGroupingUsed()
  - **boolean** isParseIntegerOnly()
  - **Number** parse(String) throws ParseException
  - **abstract** Number parse(String, ParsePosition)
  - **class** ParseException extends Exception
  - **ParseException**(String,int)
  - **class** ParsePosition
  - **ParsePosition**(int)
  - **boolean** equals(Object)
  - **int** getErrorIndex()
  - **int** getIndex()
  - **class** RuleBasedCollator extends Collator
  - **RuleBasedCollator**(String) throws ParseException
  - **Object** clone()
  - **int** compare(String,String)
  - **boolean** equals(Object)
  - **CollationElementIterator** getCollationElementIterator(String)
  - **class** SimpleDateFormat extends DateFormat
  - **SimplifyDateFormat**()
  - **SimplifyDateFormat**(String)
  - **SimplifyDateFormat**(String, DateFormatSymbols)
  - **SimplifyDateFormat**(String, java.util.Locale)
  - **void** applyLocalizedPattern(String)
  - **void** applyPattern(String)
  - **Object** clone()
  - **boolean** equals(Object)
  - **StringBuffer** format(java.util.Date, StringBuffer, FieldPosition)
  - **final class** StringCharacterIterator implements CharacterIterator
  - **StringCharacterIterator**(String)
  - **StringCharacterIterator**(String,int)
  - **StringCharacterIterator**(String,int,int,int)
  - **Object** clone()
  - **char** current()
  - **boolean** equals(Object)
  - **char** first()
  - **int** getBeginIndex()
  - **final** Object parseObject(String, ParsePosition)
  - **void** setGroupingUsed(boolean)
  - **void** setMaximumFractionDigits(int)
  - **void** setMaximumIntegerDigits(int)
  - **void** setMinimumFractionDigits(int)
  - **void** setMinimumIntegerDigits(int)
  - **void** setParseIntegerOnly(boolean)
  - **int** getErrorOffset()
  - **int** hashCode()
  - **void** setErrorIndex(int)
  - **void** setIndex(int)
  - **String** toString()
  - **CollationElementIterator** getCollationElementIterator(CharacterIterator)
  - **CollationKey** getCollationKey(String)
  - **String** getRules()
  - **int** hashCode()
  - **java.util.Date** get2DigitYearStart()
  - **DateFormatSymbols** getDateFormatSymbols()
  - **int** hashCode()
  - **java.util.Date** parse(String,ParsePosition)
  - **void** set2DigitYearStart(java.util.Date)
  - **void** setDateFormatSymbols(DateFormatSymbols)
  - **String** toLocalizedPattern()
  - **String** toPattern()
  - **int** getEndIndex()
  - **int** getIndex()
  - **int** hashCode()
  - **char** last()
  - **char** next()
  - **char** previous()
  - **char** setIndex(int)
  - **void** setText(String)

### 999.3.13

#### java.text.resources

- **package** java.text.resources
- **class** BreakIteratorRules extends java.util.ListResourceBundle
- **BreakIteratorRules**()
- **class** BreakIteratorRules\_th extends java.util.ListResourceBundle
- **BreakIteratorRules\_th**()
- **Object**[][] getContents()
- **Object**[][] getContents()

### 999.3.14

#### java.util

- **package** java.util
- **abstract class** AbstractCollection implements Collection
- **protected** AbstractCollection()
- **boolean** add(Object)
- **boolean** addAll(Collection)
- **void** clear()
- **boolean** contains(Object)
- **boolean** containsAll(Collection)
- **boolean** isEmpty()
- **abstract** Iterator iterator()
- **boolean** remove(Object)
- **boolean** removeAll(Collection)
- **boolean** retainAll(Collection)
- **abstract** int size()
- **Object**[] toArray()
- **Object**[] toArray(Object[])
- **String** toString()
- **abstract class** AbstractList extends AbstractCollection implements List
- **protected** AbstractList()
- **void** add(int,Object)
- **boolean** add(Object)
- **boolean** addAll(int,Collection)

- ■ void clear()
- ■ boolean equals(Object)
- ■ abstract Object get(int)
- ■ int hashCode()
- ■ int indexOf(Object)
- ■ Iterator iterator()
- ■ int lastIndexOf(Object)
- ■ **abstract class AbstractMap implements Map**
- ■ protected AbstractMap()
- ■ void clear()
- ■ boolean containsKey(Object)
- ■ boolean containsValue(Object)
- ■ abstract Set entrySet()
- ■ boolean equals(Object)
- ■ Object get(Object)
- ■ int hashCode()
- ■ **abstract class AbstractSequentialList extends AbstractList**
- ■ protected AbstractSequentialList()
- ■ void add(int, Object)
- ■ boolean addAll(int, Collection)
- ■ Object get(int)
- ■ **abstract class AbstractSet extends AbstractCollection implements Set**
- ■ protected AbstractSet()
- ■ boolean equals(Object)
- ■ **class ArrayList extends AbstractList implements List, Cloneable, java.io.Serializable**
- ■ ArrayList()
- ■ ArrayList(int)
- ■ ArrayList(Collection)
- ■ void add(int, Object)
- ■ boolean add(Object)
- ■ boolean addAll(int, Collection)
- ■ boolean addAll(Collection)
- ■ void clear()
- ■ Object clone()
- ■ boolean contains(Object)
- ■ void ensureCapacity(int)
- ■ **class Arrays**
- ■ static List asList(Object[])
- ■ static int binarySearch(byte[], byte)
- ■ static int binarySearch(char[], char)
- ■ static int binarySearch(double[], double)
- ■ static int binarySearch(float[], float)
- ■ static int binarySearch(int[], int)
- ■ static int binarySearch(long[], long)
- ■ static int binarySearch(Object[], Object)
- ■ static int binarySearch(Object[], Object, Comparator)
- ■ static int binarySearch(short[], short)
- ■ static boolean equals(byte[], byte[])
- ■ static boolean equals(char[], char[])
- ■ static boolean equals(double[], double[])
- ■ static boolean equals(float[], float[])
- ■ static boolean equals(int[], int[])
- ■ static boolean equals(long[], long[])
- ■ static boolean equals(Object[], Object[])
- ■ static boolean equals(short[], short[])
- ■ static boolean equals(boolean[], boolean[])
- ■ static void fill(byte[], byte)
- ■ static void fill(byte[], int, int, byte)
- ■ static void fill(char[], char)
- ■ static void fill(char[], int, int, char)
- ■ static void fill(double[], double)
- ■ static void fill(double[], int, int, double)
- ■ static void fill(float[], float)
- ■ static void fill(float[], int, int, float)
- ■ **class BitSet implements java.io.Serializable, Cloneable**
- ■ BitSet()
- ■ BitSet(int)
- ■ void and(BitSet)
- ■ void andNot(BitSet)
- ■ ListIterator listIterator()
- ■ ListIterator listIterator(int)
- ■ protected int modCount
- ■ Object remove(int)
- ■ protected void removeRange(int, int)
- ■ Object set(int, Object)
- ■ List subList(int, int)
- ■ boolean isEmpty()
- ■ Set keySet()
- ■ Object put(Object, Object)
- ■ void putAll(Map)
- ■ Object remove(Object)
- ■ int size()
- ■ String toString()
- ■ Collection values()
- ■ Iterator iterator()
- ■ abstract ListIterator listIterator(int)
- ■ Object remove(int)
- ■ Object set(int, Object)
- ■ int hashCode()
- ■ boolean removeAll(Collection)
- ■ Object get(int)
- ■ int indexOf(Object)
- ■ boolean isEmpty()
- ■ int lastIndexOf(Object)
- ■ Object remove(int)
- ■ protected void removeRange(int, int)
- ■ Object set(int, Object)
- ■ int size()
- ■ Object[] toArray()
- ■ Object[] toArray(Object[])
- ■ void trimToSize()
- ■ static void fill(int[], int)
- ■ static void fill(int[], int, int, int)
- ■ static void fill(long[], int, int, long)
- ■ static void fill(long[], long)
- ■ static void fill(Object[], int, int, Object)
- ■ static void fill(Object[], Object)
- ■ static void fill(short[], int, int, short)
- ■ static void fill(short[], short)
- ■ static void fill(boolean[], int, int, boolean)
- ■ static void fill(boolean[], boolean)
- ■ static void sort(byte[])
- ■ static void sort(byte[], int, int)
- ■ static void sort(char[])
- ■ static void sort(char[], int, int)
- ■ static void sort(double[])
- ■ static void sort(double[], int, int)
- ■ static void sort(float[])
- ■ static void sort(float[], int, int)
- ■ static void sort(int[])
- ■ static void sort(int[], int, int)
- ■ static void sort(long[])
- ■ static void sort(long[], int, int)
- ■ static void sort(Object[])
- ■ static void sort(Object[], int, int)
- ■ static void sort(Object[], int, int, Comparator)
- ■ static void sort(Object[], Comparator)
- ■ static void sort(short[])
- ■ static void sort(short[], int, int)
- ■ void clear(int)
- ■ Object clone()
- ■ boolean equals(Object)
- ■ boolean get(int)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>■ int hashCode()</li> <li>■ int length()</li> <li>■ void or(BitSet)</li> <li>■ void set(int)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>■ int size()</li> <li>■ String toString()</li> <li>■ void xor(BitSet)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <p>■ <b>abstract class Calendar implements java.io.Serializable, Cloneable</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>■ protected Calendar()</li> <li>■ protected Calendar(TimeZone,Locale)</li> <li>■ abstract void add(int,int)</li> <li>■ boolean after(Object)</li> <li>■ final static int AM</li> <li>■ final static int AM_PM</li> <li>■ final static int APRIL</li> <li>■ protected boolean areFieldsSet</li> <li>■ final static int AUGUST</li> <li>■ boolean before(Object)</li> <li>■ final void clear()</li> <li>■ final void clear(int)</li> <li>■ Object clone()</li> <li>■ protected void complete()</li> <li>■ abstract protected void computeFields()</li> <li>■ abstract protected void computeTime()</li> <li>■ final static int DATE</li> <li>■ final static int DAY_OF_MONTH</li> <li>■ final static int DAY_OF_WEEK</li> <li>■ final static int DAY_OF_WEEK_IN_MONTH</li> <li>■ final static int DAY_OF_YEAR</li> <li>■ final static int DECEMBER</li> <li>■ final static int DST_OFFSET</li> <li>■ boolean equals(Object)</li> <li>■ final static int ERA</li> <li>■ final static int FEBRUARY</li> <li>■ final static int FIELD_COUNT</li> <li>■ protected int[] fields</li> <li>■ final static int FRIDAY</li> <li>■ final int get(int)</li> <li>■ int getActualMaximum(int)</li> <li>■ int getActualMinimum(int)</li> <li>■ static Locale[] getAvailableLocales()</li> <li>■ int getFirstDayOfWeek()</li> <li>■ abstract int getGreatestMinimum(int)</li> <li>■ static Calendar getInstance()</li> <li>■ static Calendar getInstance(Locale)</li> <li>■ static Calendar getInstance(TimeZone)</li> <li>■ static Calendar getInstance(TimeZone, Locale)</li> <li>■ abstract int getLeastMaximum(int)</li> <li>■ abstract int getMaximum(int)</li> <li>■ int getMinimalDaysInFirstWeek()</li> <li>■ abstract int getMinimum(int)</li> <li>■ final Date getTime()</li> <li>■ protected long getTimelnMillis()</li> <li>■ TimeZone getTimeZone()</li> </ul> | <ul style="list-style-type: none"> <li>■ int hashCode()</li> <li>■ final static int HOUR</li> <li>■ final static int HOUR_OF_DAY</li> <li>■ final protected int internalGet(int)</li> <li>■ boolean isLenient()</li> <li>■ final boolean isSet(int)</li> <li>■ protected boolean[] isSet</li> <li>■ protected boolean isTimeSet</li> <li>■ final static int JANUARY</li> <li>■ final static int JULY</li> <li>■ final static int JUNE</li> <li>■ final static int MARCH</li> <li>■ final static int MAY</li> <li>■ final static int MILLisecond</li> <li>■ final static int MINUTE</li> <li>■ final static int MONDAY</li> <li>■ final static int MONTH</li> <li>■ final static int NOVEMBER</li> <li>■ final static int OCTOBER</li> <li>■ final static int PM</li> <li>■ void roll(int,int)</li> <li>■ abstract void roll(int,boolean)</li> <li>■ final static int SATURDAY</li> <li>■ final static int SECOND</li> <li>■ final static int SEPTEMBER</li> <li>■ final void set(int,int)</li> <li>■ final void set(int,int,int)</li> <li>■ final void set(int,int,int,int,int)</li> <li>■ void setFirstDayOfWeek(int)</li> <li>■ void setLenient(boolean)</li> <li>■ void setMinimalDaysInFirstWeek(int)</li> <li>■ final void setTime(Date)</li> <li>■ protected void setTimeInMillis(long)</li> <li>■ void setTimeZone(TimeZone)</li> <li>■ final static int SUNDAY</li> <li>■ final static int THURSDAY</li> <li>■ protected long time</li> <li>■ String toString()</li> <li>■ final static int TUESDAY</li> <li>■ final static int UNDECIMBER</li> <li>■ final static int WEDNESDAY</li> <li>■ final static int WEEK_OF_MONTH</li> <li>■ final static int WEEK_OF_YEAR</li> <li>■ final static int YEAR</li> <li>■ final static int ZONE_OFFSET</li> </ul> |
| <p>■ <b>interface Collection</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>■ abstract boolean add(Object)</li> <li>■ abstract boolean addAll(Collection)</li> <li>■ abstract void clear()</li> <li>■ abstract boolean contains(Object)</li> <li>■ abstract boolean containsAll(Collection)</li> <li>■ abstract boolean equals(Object)</li> <li>■ abstract int hashCode()</li> <li>■ abstract boolean isEmpty()</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>■ abstract Iterator iterator()</li> <li>■ abstract boolean remove(Object)</li> <li>■ abstract boolean removeAll(Collection)</li> <li>■ abstract boolean retainAll(Collection)</li> <li>■ abstract int size()</li> <li>■ abstract Object[] toArray()</li> <li>■ abstract Object[] toArray(Object[])</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>■ <b>class Collections</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>■ static int binarySearch(List,Object)</li> <li>■ static int binarySearch(List,Object, Comparator)</li> <li>■ static void copy(List,List)</li> <li>■ final static List EMPTY_LIST</li> <li>■ final static Map EMPTY_MAP</li> <li>■ final static Set EMPTY_SET</li> <li>■ static Enumeration enumeration(Collection)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>■ static void fill(List,Object)</li> <li>■ static Object max(Collection)</li> <li>■ static Object max(Collection, Comparator)</li> <li>■ static Object min(Collection)</li> <li>■ static Object min(Collection,Comparator)</li> <li>■ static List nCopies(int,Object)</li> <li>■ static void reverse(List)</li> <li>■ static Comparator reverseOrder()</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

- ■ static void shuffle(List)
- ■ static void shuffle(List,Random)
- ■ static Set singleton(Object)
- ■ static List singletonList(Object)
- ■ static Map singletonMap(Object,Object)
- ■ static void sort(List)
- ■ static void sort(List,Comparator)
- ■ static Collection
- ■ synchronizedCollection(Collection)
- ■ static List synchronizedList(List)
- ■ static Map synchronizedMap(Map)
- ■ static Set synchronizedSet(Set)
- ■ static SortedMap
- ■ synchronizedSortedMap(SortedMap)
- ■ static SortedSet
- ■ synchronizedSortedSet(SortedSet)
- ■ static Collection
- ■ unmodifiableCollection(Collection)
- ■ static List unmodifiableList(List)
- ■ static Map unmodifiableMap(Map)
- ■ static Set unmodifiableSet(Set)
- ■ static SortedMap
- ■ unmodifiableSortedMap(SortedMap)
- ■ static SortedSet
- ■ unmodifiableSortedSet(SortedSet)
- ■ **interface Comparator**
- ■ abstract int compare(Object,Object)
- ■ **class ConcurrentModificationException extends RuntimeException**
- ■ ConcurrentModificationException()
- ■ ConcurrentModificationException(String)
- ■ **class Date implements java.io.Serializable , Cloneable , Comparable**
- ■ Date()
- ■ Date(long)
- ■ boolean after(Date)
- ■ boolean before(Date)
- ■ Object clone()
- ■ int compareTo(Object)
- ■ **abstract class Dictionary**
- ■ Dictionary()
- ■ abstract Enumeration elements()
- ■ abstract Object get(Object)
- ■ abstract boolean isEmpty()
- ■ **class EmptyStackException extends RuntimeException**
- ■ EmptyStackException()
- ■ **interface Enumeration**
- ■ abstract boolean hasMoreElements()
- ■ **interface EventListener**
- ■ **class EventObject implements java.io.Serializable**
- ■ EventObject(Object)
- ■ Object getSource()
- ■ **class GregorianCalendar extends Calendar**
- ■ GregorianCalendar()
- ■ GregorianCalendar(int,int,int)
- ■ GregorianCalendar(int,int,int,int)
- ■ GregorianCalendar(int,int,int,int,int)
- ■ GregorianCalendar(Locale)
- ■ GregorianCalendar(TimeZone)
- ■ GregorianCalendar(TimeZone,Locale)
- ■ final static int AD
- ■ void add(int,int)
- ■ final static int BC
- ■ protected void computeFields()
- ■ protected void computeTime()
- ■ boolean equals(Object)
- ■ **class HashMap extends AbstractMap implements Map , Cloneable , java.io.Serializable**
- ■ HashMap()
- ■ HashMap(int)
- ■ HashMap(int,float)
- ■ HashMap(Map)
- ■ void clear()
- ■ Object clone()
- ■ boolean containsKey(Object)
- ■ boolean containsValue(Object)
- ■ Set entrySet()
- ■ **class HashSet extends AbstractSet implements Set , Cloneable , java.io.Serializable**
- ■ HashSet()
- ■ HashSet(int)
- ■ HashSet(int,float)
- ■ HashSet(Collection)
- ■ boolean add(Object)
- ■ void clear()
- ■ **class Hashtable extends Dictionary implements Map , Cloneable , java.io.Serializable**
- ■ Hashtable()
- ■ abstract boolean equals(Object)
- ■ int compareTo(Date)
- ■ boolean equals(Object)
- ■ long getTime()
- ■ int hashCode()
- ■ void setTime(long)
- ■ String toString()
- ■ abstract Enumeration keys()
- ■ abstract Object put(Object,Object)
- ■ abstract Object remove(Object)
- ■ abstract int size()
- ■ abstract Object nextElement()
- ■ protected Object source
- ■ String toString()
- ■ int getActualMaximum(int)
- ■ int getActualMinimum(int)
- ■ int getGreatestMinimum(int)
- ■ final Date getGregorianCalendarChange()
- ■ int getLeastMaximum(int)
- ■ int getMaximum(int)
- ■ int getMinimum(int)
- ■ int hashCode()
- ■ boolean isLeapYear(int)
- ■ void roll(int,int)
- ■ void roll(int,boolean)
- ■ void setGregorianCalendarChange(Date)
- ■ Object get(Object)
- ■ boolean isEmpty()
- ■ Set keySet()
- ■ Object put(Object,Object)
- ■ void putAll(Map)
- ■ Object remove(Object)
- ■ int size()
- ■ Collection values()
- ■ Object clone()
- ■ boolean contains(Object)
- ■ boolean isEmpty()
- ■ Iterator iterator()
- ■ boolean remove(Object)
- ■ int size()
- ■ Hashtable(int)

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■ ■ Hashtable(int,float)
■ ■ Hashtable(Map)
■ ■ void clear()
■ ■ Object clone()
■ ■ boolean contains(Object)
■ ■ boolean containsKey(Object)
■ ■ boolean containsValue(Object)
■ ■ Enumeration elements()
■ ■ Set entrySet()
■ ■ boolean equals(Object)
■ ■ Object get(Object)
■ ■ interface Iterator
■ ■ abstract boolean hasNext()
■ ■ abstract Object next()

■ ■ class LinkedList extends AbstractSequentialList implements List , Cloneable , java.io.Serializable
■ ■ LinkedList()
■ ■ LinkedList(Collection)
■ ■ void add(int,Object)
■ ■ boolean add(Object)
■ ■ boolean addAll(int,Collection)
■ ■ boolean addAll(Collection)
■ ■ void addFirst(Object)
■ ■ void addLast(Object)
■ ■ void clear()
■ ■ Object clone()
■ ■ boolean contains(Object)
■ ■ Object get(int)
■ ■ Object getFirst()
■ ■ interface List extends Collection
■ ■ abstract void add(int,Object)
■ ■ abstract boolean add(Object)
■ ■ abstract boolean addAll(int,Collection)
■ ■ abstract boolean addAll(Collection)
■ ■ abstract void clear()
■ ■ abstract boolean contains(Object)
■ ■ abstract boolean containsAll(Collection)
■ ■ abstract boolean equals(Object)
■ ■ abstract Object get(int)
■ ■ abstract int hashCode()
■ ■ abstract int indexOf(Object)
■ ■ abstract boolean isEmpty()
■ ■ abstract Iterator iterator()
■ ■ interface ListIterator extends Iterator
■ ■ abstract void add(Object)
■ ■ abstract boolean hasNext()
■ ■ abstract boolean hasPrevious()
■ ■ abstract Object next()
■ ■ abstract int nextIndex()
■ ■ abstract class ListResourceBundle extends ResourceBundle
■ ■ ListResourceBundle()
■ ■ abstract protected Object[][]
 getContents()
■ ■ final class Locale implements Cloneable , java.io.Serializable
■ ■ Locale(String,String)
■ ■ Locale(String,String,String)
■ ■ final static Locale CANADA
■ ■ final static Locale CANADA_FRENCH
■ ■ final static Locale CHINA
■ ■ final static Locale CHINESE
■ ■ Object clone()
■ ■ final static Locale ENGLISH
■ ■ boolean equals(Object)
■ ■ final static Locale FRANCE
■ ■ final static Locale FRENCH
■ ■ final static Locale GERMAN
■ ■ final static Locale GERMANY
■ ■ static Locale[] getAvailableLocales()
■ ■ String getCountry()
■ ■ static Locale getDefault()
■ ■ final String getDisplayCountry()
■ ■ String getDisplayCountry(Locale)
■ ■ int hashCode()
■ ■ boolean isEmpty()
■ ■ Enumeration keys()
■ ■ Set keySet()
■ ■ Object put(Object,Object)
■ ■ void putAll(Map)
■ ■ protected void rehash()
■ ■ Object remove(Object)
■ ■ int size()
■ ■ String toString()
■ ■ Collection values()
■ ■ abstract void remove()
■ ■ Object getLast()
■ ■ int indexOf(Object)
■ ■ int lastIndexOf(Object)
■ ■ ListIterator listIterator(int)
■ ■ Object remove(int)
■ ■ boolean remove(Object)
■ ■ Object removeFirst()
■ ■ Object removeLast()
■ ■ Object set(int,Object)
■ ■ int size()
■ ■ Object[] toArray()
■ ■ Object[] toArray(Object[])
■ ■ abstract int lastIndexOf(Object)
■ ■ abstract ListIterator listIterator()
■ ■ abstract ListIterator listIterator(int)
■ ■ abstract Object remove(int)
■ ■ abstract boolean remove(Object)
■ ■ abstract boolean removeAll(Collection)
■ ■ abstract boolean retainAll(Collection)
■ ■ abstract Object set(int,Object)
■ ■ abstract int size()
■ ■ abstract List subList(int,int)
■ ■ abstract Object[] toArray()
■ ■ abstract Object[] toArray(Object[])
■ ■ abstract Object previous()
■ ■ abstract int previousIndex()
■ ■ abstract void remove()
■ ■ abstract void set(Object)
■ ■ Enumeration getKeys()
■ ■ final Object handleGetObject(String)
■ ■ final String getDisplayLanguage()
■ ■ String getDisplayLanguage(Locale)
■ ■ final String getDisplayName()
■ ■ String getDisplayName(Locale)
■ ■ final String getDisplayVariant()
■ ■ String getDisplayVariant(Locale)
■ ■ String getISO3Country() throws
 MissingResourceException
■ ■ String getISO3Language() throws
 MissingResourceException
■ ■ static String[] getISOCountries()
■ ■ static String[] getISOLanguages()
■ ■ String getLanguage()
■ ■ String getVariant()
■ ■ int hashCode()
■ ■ final static Locale ITALIAN
■ ■ final static Locale ITALY
■ ■ final static Locale JAPAN

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|                                                                                                |                                                                                     |
|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| ■ final static Locale JAPANESE                                                                 | ■ final static Locale TAIWAN                                                        |
| ■ final static Locale KOREA                                                                    | ■ final String toString()                                                           |
| ■ final static Locale KOREAN                                                                   | ■ final static Locale TRADITIONAL_CHINESE                                           |
| ■ final static Locale PRC                                                                      | ■ final static Locale UK                                                            |
| ■ static void setDefault(Locale)                                                               | ■ final static Locale US                                                            |
| ■ final static Locale SIMPLIFIED_CHINESE                                                       |                                                                                     |
| ■ <b>interface Map</b>                                                                         |                                                                                     |
| ■ abstract void clear()                                                                        | ■ abstract boolean isEmpty()                                                        |
| ■ abstract boolean containsKey(Object)                                                         | ■ abstract Set keySet()                                                             |
| ■ abstract boolean containsValue(Object)                                                       | ■ abstract Object put(Object, Object)                                               |
| ■ abstract Set entrySet()                                                                      | ■ abstract void putAll(Map)                                                         |
| ■ abstract boolean equals(Object)                                                              | ■ abstract Object remove(Object)                                                    |
| ■ abstract Object get(Object)                                                                  | ■ abstract int size()                                                               |
| ■ abstract int hashCode()                                                                      | ■ abstract Collection values()                                                      |
| ■ <b>interface Map.Entry</b>                                                                   |                                                                                     |
| ■ abstract boolean equals(Object)                                                              | ■ abstract int hashCode()                                                           |
| ■ abstract Object getKey()                                                                     | ■ abstract Object setValue(Object)                                                  |
| ■ abstract Object getValue()                                                                   |                                                                                     |
| ■ <b>class MissingResourceException extends RuntimeException</b>                               |                                                                                     |
| ■ MissingResourceException(String, String, String)                                             | ■ String getClassName()                                                             |
|                                                                                                | ■ String getKey()                                                                   |
| ■ <b>class NoSuchElementException extends RuntimeException</b>                                 |                                                                                     |
| ■ NoSuchElementException()                                                                     | ■ NoSuchElementException(String)                                                    |
| ■ <b>class Observable</b>                                                                      |                                                                                     |
| ■ Observable()                                                                                 | ■ void deleteObservers()                                                            |
| ■ void addObserver(Observer)                                                                   | ■ boolean hasChanged()                                                              |
| ■ protected void clearChanged()                                                                | ■ void notifyObservers()                                                            |
| ■ int countObservers()                                                                         | ■ void notifyObservers(Object)                                                      |
| ■ void deleteObserver(Observer)                                                                | ■ protected void setChanged()                                                       |
| ■ <b>interface Observer</b>                                                                    |                                                                                     |
| ■ abstract void update(Observable, Object)                                                     |                                                                                     |
| ■ <b>class Properties extends Hashtable</b>                                                    |                                                                                     |
| ■ Properties()                                                                                 | ■ void load(java.io.InputStream) throws java.io.IOException                         |
| ■ Properties(Properties)                                                                       | ■ Enumeration propertyNames()                                                       |
| ■ protected Properties defaults                                                                | ■ void save(java.io.OutputStream, String)                                           |
| ■ String getProperty(String)                                                                   | ■ Object setProperty(String, String)                                                |
| ■ String getProperty(String, String)                                                           | ■ void store(java.io.OutputStream, String) throws java.io.IOException               |
| ■ void list(java.io.PrintWriter)                                                               |                                                                                     |
| ■ void list(java.io.PrintWriter)                                                               |                                                                                     |
| ■ <b>final class PropertyPermission extends java.security.BasicPermission</b>                  |                                                                                     |
| ■ PropertyPermission(String, String)                                                           | ■ boolean implies(java.security.Permission)                                         |
| ■ boolean equals(Object)                                                                       | ■ java.security.PermissionCollection newPermissionCollection()                      |
| ■ String getActions()                                                                          |                                                                                     |
| ■ int hashCode()                                                                               |                                                                                     |
| ■ <b>class PropertyResourceBundle extends ResourceBundle</b>                                   |                                                                                     |
| ■ PropertyResourceBundle(java.io.InputStream) throws java.io.IOException                       | ■ Enumeration getKeys()                                                             |
|                                                                                                | ■ Object handleGetObject(String)                                                    |
| ■ <b>class Random implements java.io.Serializable</b>                                          |                                                                                     |
| ■ Random()                                                                                     | ■ float nextFloat()                                                                 |
| ■ Random(long)                                                                                 | ■ double nextGaussian()                                                             |
| ■ protected int next(int)                                                                      | ■ int nextInt()                                                                     |
| ■ boolean nextBoolean()                                                                        | ■ int nextInt(int)                                                                  |
| ■ void nextBytes(byte[])                                                                       | ■ long nextLong()                                                                   |
| ■ double nextDouble()                                                                          | ■ void setSeed(long)                                                                |
| ■ <b>abstract class ResourceBundle</b>                                                         |                                                                                     |
| ■ ResourceBundle()                                                                             | ■ final Object getObject(String) throws MissingResourceException                    |
| ■ final static ResourceBundle getBundle(String) throws MissingResourceException                | ■ final String getString(String) throws MissingResourceException                    |
| ■ final static ResourceBundle getBundle(String, Locale)                                        | ■ final String[] getStringArray(String) throws MissingResourceException             |
| ■ static ResourceBundle getBundle(String, Locale, ClassLoader) throws MissingResourceException | ■ abstract protected Object handleGetObject(String) throws MissingResourceException |
| ■ abstract Enumeration getKeys()                                                               | ■ protected ResourceBundle parent                                                   |
| ■ Locale getLocale()                                                                           | ■ protected void setParent(ResourceBundle)                                          |
| ■ <b>interface Set extends Collection</b>                                                      |                                                                                     |
| ■ abstract boolean add(Object)                                                                 | ■ abstract boolean addAll(Collection)                                               |

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■ ■ abstract void clear()
■ ■ abstract boolean contains(Object)
■ ■ abstract boolean containsAll(Collection)
■ ■ abstract boolean equals(Object)
■ ■ abstract int hashCode()
■ ■ abstract boolean isEmpty()
■ ■ abstract Iterator iterator()

■ ■ class SimpleTimeZone extends TimeZone
■ ■ SimpleTimeZone(int,String)
■ ■ SimpleTimeZone(int,String,int,int,int,int,int,int,int,int)
■ ■ SimpleTimeZone(int,String,int,int,int,int,int,int,int,int,int)
■ ■ Object clone()
■ ■ boolean equals(Object)
■ ■ int getDSTSavings()
■ ■ int getOffset(int,int,int,int,int,int)
■ ■ int getRawOffset()
■ ■ int hashCode()
□ ■ boolean hasSameRules(TimeZone)

■ ■ interface SortedMap extends Map
■ ■ abstract Comparator comparator()
■ ■ abstract Object firstKey()
■ ■ abstract SortedMap headMap(Object)
■ ■ abstract Object lastKey()

■ ■ interface SortedSet extends Set
■ ■ abstract Comparator comparator()
■ ■ abstract Object first()
■ ■ abstract SortedSet headSet(Object)
■ ■ abstract Object last()

■ ■ class Stack extends Vector
■ ■ Stack()
■ ■ boolean empty()
■ ■ Object peek()

■ ■ class StringTokenizer implements Enumeration
■ ■ StringTokenizer(String)
■ ■ StringTokenizer(String,String)
■ ■ StringTokenizer(String,String,boolean)
■ ■ int countTokens()
■ ■ boolean hasMoreElements()

□ ■ class Timer
□ ■ Timer()
□ ■ Timer(boolean)
□ ■ void cancel()
□ ■ void schedule(TimerTask,long)
□ ■ void schedule(TimerTask,long,long)
□ ■ void schedule(TimerTask,Date)

□ ■ abstract class TimerTask implements Runnable
□ ■ protected TimerTask()
□ ■ boolean cancel()

■ ■ abstract class TimeZone implements java.io.Serializable , Cloneable
■ ■ TimeZone()
■ ■ Object clone()
■ ■ static String[] getAvailableIDs()
■ ■ static String[] getAvailableIDs(int)
■ ■ static TimeZone getDefault()
□ ■ final String getDisplayName()
□ ■ final String getDisplayName(Locale)
□ ■ final String getDisplayName(boolean,int)
□ ■ String getDisplayName(boolean,int,Locale)
■ ■ String getID()

□ ■ class TooManyListenersException extends Exception
□ ■ TooManyListenersException()
□ ■ TooManyListenersException(String)

■ ■ class TreeMap extends AbstractMap implements SortedMap , Cloneable , java.io.Serializable
■ ■ TreeMap()
■ ■ TreeMap(Comparator)
■ ■ TreeMap(Map)
■ ■ TreeMap(SortedMap)

■ ■ abstract boolean remove(Object)
■ ■ abstract boolean removeAll(Collection)
■ ■ abstract boolean retainAll(Collection)
■ ■ abstract int size()
■ ■ abstract Object[] toArray()
■ ■ abstract Object[] toArray(Object[])

■ ■ boolean inDaylightTime(Date)
□ ■ void setDSTSavings(int)
■ ■ void setEndRule(int,int,int)
■ ■ void setEndRule(int,int,int,int)
■ ■ void setEndRule(int,int,int,int,boolean)
■ ■ void setRawOffset(int)
■ ■ void setStartRule(int,int,int)
■ ■ void setStartRule(int,int,int,int)
■ ■ void setStartRule(int,int,int,int,boolean)
■ ■ void setStartYear(int)
■ ■ String toString()
■ ■ boolean useDaylightTime()

■ ■ abstract SortedMap subMap(Object, Object)
■ ■ abstract SortedMap tailMap(Object)

■ ■ abstract SortedSet subSet(Object, Object)
■ ■ abstract SortedSet tailSet(Object)

■ ■ Object pop()
■ ■ Object push(Object)
■ ■ int search(Object)

■ ■ boolean hasMoreTokens()
■ ■ Object nextElement()
■ ■ String nextToken()
■ ■ String nextToken(String)

□ ■ void schedule(TimerTask,Date,long)
□ ■ void scheduleAtFixedRate(TimerTask, long,long)
□ ■ void scheduleAtFixedRate(TimerTask, Date,long)

□ ■ abstract void run()
□ ■ long scheduledExecutionTime()

■ ■ abstract int getOffset(int,int,int,int,int,int)
■ ■ abstract int getRawOffset()
■ ■ static TimeZone getTimeZone(String)
□ ■ boolean hasSameRules(TimeZone)
■ ■ abstract boolean inDaylightTime(Date)
□ ■ final static int LONG
■ ■ static void setDefault(TimeZone)
■ ■ void setID(String)
■ ■ abstract void setRawOffset(int)
□ ■ final static int SHORT
■ ■ abstract boolean useDaylightTime()

```



|                                                                                                  |                                        |
|--------------------------------------------------------------------------------------------------|----------------------------------------|
| ■ boolean containsValue(Object)                                                                  | ■ Object put(Object, Object)           |
| ■ Set entrySet()                                                                                 | ■ void putAll(Map)                     |
| ■ Object firstKey()                                                                              | ■ Object remove(Object)                |
| ■ Object get(Object)                                                                             | ■ int size()                           |
| ■ SortedMap headMap(Object)                                                                      | ■ SortedMap subMap(Object, Object)     |
| ■ Set keySet()                                                                                   | ■ SortedMap tailMap(Object)            |
| ■ Object lastKey()                                                                               | ■ Collection values()                  |
| ■ <b>class TreeSet extends AbstractSet implements SortedSet, Cloneable, java.io.Serializable</b> |                                        |
| ■ TreeSet()                                                                                      | ■ Object first()                       |
| ■ TreeSet(Collection)                                                                            | ■ SortedSet headSet(Object)            |
| ■ TreeSet(Comparator)                                                                            | ■ boolean isEmpty()                    |
| ■ TreeSet(SortedSet)                                                                             | ■ Iterator iterator()                  |
| ■ boolean add(Object)                                                                            | ■ Object last()                        |
| ■ boolean addAll(Collection)                                                                     | ■ boolean remove(Object)               |
| ■ void clear()                                                                                   | ■ int size()                           |
| ■ Object clone()                                                                                 | ■ SortedSet subSet(Object, Object)     |
| ■ Comparator comparator()                                                                        | ■ SortedSet tailSet(Object)            |
| ■ boolean contains(Object)                                                                       |                                        |
| ■ <b>class Vector extends AbstractList implements List, Cloneable, java.io.Serializable</b>      |                                        |
| ■ Vector()                                                                                       | ■ int indexOf(Object)                  |
| ■ Vector(int)                                                                                    | ■ int indexOf(Object, int)             |
| ■ Vector(int, int)                                                                               | ■ void insertElementAt(Object, int)    |
| ■ Vector(Collection)                                                                             | ■ boolean isEmpty()                    |
| ■ void add(int, Object)                                                                          | ■ Object lastElement()                 |
| ■ boolean add(Object)                                                                            | ■ int lastIndexOf(Object)              |
| ■ boolean addAll(int, Collection)                                                                | ■ int lastIndexOf(Object, int)         |
| ■ boolean addAll(Collection)                                                                     | ■ Object remove(int)                   |
| ■ void addElement(Object)                                                                        | ■ boolean remove(Object)               |
| ■ int capacity()                                                                                 | ■ boolean removeAll(Collection)        |
| ■ protected int capacityIncrement                                                                | ■ void removeAllElements()             |
| ■ void clear()                                                                                   | ■ boolean removeElement(Object)        |
| ■ Object clone()                                                                                 | ■ void removeElementAt(int)            |
| ■ boolean contains(Object)                                                                       | ■ protected void removeRange(int, int) |
| ■ boolean containsAll(Collection)                                                                | ■ boolean retainAll(Collection)        |
| ■ void copyInto(Object[])                                                                        | ■ Object set(int, Object)              |
| ■ Object elementAt(int)                                                                          | ■ void setElementAt(Object, int)       |
| ■ protected int elementCount                                                                     | ■ void setSize(int)                    |
| ■ protected Object[] elementData                                                                 | ■ int size()                           |
| ■ Enumeration elements()                                                                         | ■ List subList(int, int)               |
| ■ void ensureCapacity(int)                                                                       | ■ Object[] toArray()                   |
| ■ boolean equals(Object)                                                                         | ■ Object[] toArray(Object[])           |
| ■ Object firstElement()                                                                          | ■ String toString()                    |
| ■ Object get(int)                                                                                | ■ void trimToSize()                    |
| ■ int hashCode()                                                                                 |                                        |
| ■ <b>class WeakHashMap extends AbstractMap implements Map</b>                                    |                                        |
| ■ WeakHashMap()                                                                                  | ■ Set entrySet()                       |
| ■ WeakHashMap(int)                                                                               | ■ Object get(Object)                   |
| ■ WeakHashMap(int, float)                                                                        | ■ boolean isEmpty()                    |
| ■ WeakHashMap(Map)                                                                               | ■ Object put(Object, Object)           |
| ■ void clear()                                                                                   | ■ Object remove(Object)                |
| ■ boolean containsKey(Object)                                                                    | ■ int size()                           |

## 999.3.15

### java.util.jar

|                                                               |                                    |
|---------------------------------------------------------------|------------------------------------|
| □ <b>package java.util.jar</b>                                |                                    |
| □ <b>class Attributes implements Cloneable, java.util.Map</b> |                                    |
| □ Attributes()                                                | □ String getValue(Attributes.Name) |
| □ Attributes(int)                                             | □ int hashCode()                   |
| □ Attributes(Attributes)                                      | □ boolean isEmpty()                |
| □ void clear()                                                | □ java.util.Set keySet()           |
| □ Object clone()                                              | □ protected java.util.Map map      |
| □ boolean containsKey(Object)                                 | □ Object put(Object, Object)       |
| □ boolean containsValue(Object)                               | □ void putAll(java.util.Map)       |
| □ java.util.Set entrySet()                                    | □ String putValue(String, String)  |
| □ boolean equals(Object)                                      | □ Object remove(Object)            |
| □ Object get(Object)                                          | □ int size()                       |
| □ String getValue(String)                                     | □ java.util.Collection values()    |
| □ <b>class Attributes.Name</b>                                |                                    |
| □ Attributes.Name(String)                                     | □ final static Attributes.Name     |
| □ final static Attributes.Name CLASS_PATH                     | CONTENT_TYPE                       |
|                                                               | □ boolean equals(Object)           |

- ■ final static Attributes.Name EXTENSION\_INSTALLATION
- ■ final static Attributes.Name EXTENSION\_LIST
- ■ final static Attributes.Name EXTENSION\_NAME
- ■ int hashCode()
- ■ final static Attributes.Name IMPLEMENTATION\_TITLE
- ■ final static Attributes.Name IMPLEMENTATION\_URL
- ■ final static Attributes.Name IMPLEMENTATION\_VENDOR
- ■ final static Attributes.Name IMPLEMENTATION\_VENDOR\_ID
- ■ **class JarEntry extends java.util.zip.ZipEntry**
- ■ JarEntry(String)
- ■ JarEntry(JarEntry)
- ■ JarEntry(java.util.zip.ZipEntry)
- ■ **class JarException extends java.util.zip.ZipException**
- ■ JarException()
- ■ JarException(String)
- ■ **class JarFile extends java.util.zip.ZipFile**
- ■ JarFile(java.io.File) throws java.io.IOException
- ■ JarFile(java.io.File,boolean) throws java.io.IOException
- ■ JarFile(java.io.File,boolean,int) throws java.io.IOException
- ■ JarFile(String) throws java.io.IOException
- ■ JarFile(String,boolean) throws java.io.IOException
- ■ **class JarInputStream extends java.util.zip.ZipInputStream**
- ■ JarInputStream(java.io.InputStream) throws java.io.IOException
- ■ JarInputStream(java.io.InputStream,boolean) throws java.io.IOException
- ■ protected java.util.zip.ZipEntry createZipEntry(String)
- ■ Manifest getManifest()
- ■ **class JarOutputStream extends java.util.zip.ZipOutputStream**
- ■ JarOutputStream(java.io.OutputStream) throws java.io.IOException
- ■ JarOutputStream(java.io.OutputStream,Manifest) throws java.io.IOException
- ■ **class Manifest implements Cloneable**
- ■ Manifest()
- ■ Manifest(java.io.InputStream) throws java.io.IOException
- ■ Manifest(Manifest)
- ■ void clear()
- ■ Object clone()
- ■ boolean equals(Object)
- ■ Attributes getAttributes(String)
- ■ final static Attributes.Name IMPLEMENTATION\_VERSION
- ■ final static Attributes.Name MAIN\_CLASS
- ■ final static Attributes.Name MANIFEST\_VERSION
- ■ final static Attributes.Name SEALED
- ■ final static Attributes.Name SIGNATURE\_VERSION
- ■ final static Attributes.Name SPECIFICATION\_TITLE
- ■ final static Attributes.Name SPECIFICATION\_VENDOR
- ■ final static Attributes.Name SPECIFICATION\_VERSION
- ■ String toString()
- ■ Attributes getAttributes() throws java.io.IOException
- ■ java.security.cert.Certificate[] getCertificates()
- ■ java.util.Enumeration entries()
- ■ java.util.zip.ZipEntry getEntry(String)
- ■ java.io.InputStream getInputStream(java.util.zip.ZipEntry) throws java.io.IOException
- ■ JarEntry getJarEntry(String)
- ■ Manifest getManifest() throws java.io.IOException
- ■ final static String MANIFEST\_NAME
- ■ java.util.zip.ZipEntry getNextEntry() throws java.io.IOException
- ■ JarEntry getNextJarEntry() throws java.io.IOException
- ■ int read(byte[],int,int) throws java.io.IOException
- ■ void putNextEntry(java.util.zip.ZipEntry) throws java.io.IOException
- ■ java.util.Map getEntries()
- ■ Attributes getMainAttributes()
- ■ int hashCode()
- ■ void read(java.io.InputStream) throws java.io.IOException
- ■ void write(java.io.OutputStream) throws java.io.IOException
- ■ void update(byte[])
- ■ void update(byte[],int,int)
- ■ void update(int)
- ■ int read(byte[],int,int) throws java.io.IOException
- ■ long skip(long) throws java.io.IOException
- ■ Checksum getChecksum()

## 999.3.16

## java.util.zip

- ■ **package java.util.zip**
- ■ **class Adler32 implements Checksum**
- ■ Adler32()
- ■ long getValue()
- ■ void reset()
- ■ **class CheckedInputStream extends java.io.FilterInputStream**
- ■ CheckedInputStream(java.io.InputStream,Checksum)
- ■ Checksum getChecksum()
- ■ int read() throws java.io.IOException
- ■ **class CheckedOutputStream extends java.io.FilterOutputStream**
- ■ CheckedOutputStream(java.io.OutputStream,Checksum)
- ■ Checksum getChecksum()
- ■ void update(byte[])
- ■ void update(byte[],int,int)
- ■ void update(int)
- ■ int read(byte[],int,int) throws java.io.IOException
- ■ long skip(long) throws java.io.IOException
- ■ Checksum getChecksum()

- ❑ **void write(byte[],int,int) throws java.io.IOException**
- **interface Checksum**
  - abstract long getValue()
  - abstract void reset()
- **class CRC32 implements Checksum**
  - CRC32()
  - long getValue()
  - void reset()
- **class DataFormatException extends Exception**
  - DataFormatException()
- **class Deflater**
  - Deflater()
  - Deflater(int)
  - Deflater(int,boolean)
  - final static int BEST\_COMPRESSION
  - final static int BEST\_SPEED
  - final static int DEFAULT\_COMPRESSION
  - final static int DEFAULT\_STRATEGY
  - int deflate(byte[])
  - int deflate(byte[],int,int)
  - final static int DEFLATED
  - void end()
  - final static int FILTERED
  - protected void finalize()
  - void finish()
- **class DeflaterOutputStream extends java.io.FilterOutputStream**
  - DeflaterOutputStream(java.io.OutputStream)
  - DeflaterOutputStream(java.io.OutputStream,Deflater)
  - DeflaterOutputStream(java.io.OutputStream,Deflater,int)
  - protected byte[] buf
- **class GZIPInputStream extendsInflaterInputStream**
  - GZIPInputStream(java.io.InputStream) throws java.io.IOException
  - GZIPInputStream(java.io.InputStream,int) throws java.io.IOException
  - void close() throws java.io.IOException
- **class GZIPOutputStream extends DeflaterOutputStream**
  - GZIPOutputStream(java.io.OutputStream) throws java.io.IOException
  - GZIPOutputStream(java.io.OutputStream,int) throws java.io.IOException
- **class Inflater**
  - Inflater()
  - Inflater(boolean)
  - void end()
  - protected void finalize()
  - boolean finished()
  - int getAdler()
  - int getRemaining()
  - int getTotalIn()
  - int getTotalOut()
  - int inflate(byte[]) throws DataFormatException
- **class InflaterInputStream extends java.io.FilterInputStream**
  - InflaterInputStream(java.io.InputStream)
  - InflaterInputStream(java.io.InputStream,Inflater)
  - InflaterInputStream(java.io.InputStream,Inflater,int)
  - int available() throws java.io.IOException
  - protected byte[] buf
  - void close() throws java.io.IOException
- **void write(int) throws java.io.IOException**
- **abstract void update(byte[],int,int)**
- **abstract void update(int)**
- **void update(byte[])**
- **void update(byte[],int,int)**
- **void update(int)**
- **DataFormatException(String)**
- **boolean finished()**
- **int getAdler()**
- **int getTotalIn()**
- **int getTotalOut()**
- **final static int HUFFMAN\_ONLY**
- **boolean needsInput()**
- **final static int NO\_COMPRESSION**
- **void reset()**
- **void setDictionary(byte[])**
- **void setDictionary(byte[],int,int)**
- **void setInput(byte[])**
- **void setInput(byte[],int,int)**
- **void setLevel(int)**
- **void setStrategy(int)**
- **void close() throws java.io.IOException**
- **protected Deflater def**
- **protected void deflate() throws java.io.IOException**
- **void finish() throws java.io.IOException**
- **void write(byte[],int,int) throws java.io.IOException**
- **void write(int) throws java.io.IOException**
- **protected CRC32 crc**
- **protected boolean eos**
- **final static int GZIP\_MAGIC**
- **int read(byte[],int,int) throws java.io.IOException**
- **void close() throws java.io.IOException**
- **protected CRC32 crc**
- **void finish() throws java.io.IOException**
- **void write(byte[],int,int) throws java.io.IOException**
- **int inflate(byte[],int,int) throws DataFormatException**
- **boolean needsDictionary()**
- **boolean needsInput()**
- **void reset()**
- **void setDictionary(byte[])**
- **void setDictionary(byte[],int,int)**
- **void setInput(byte[])**
- **void setInput(byte[],int,int)**
- **protected void fill() throws java.io.IOException**
- **protected Inflater inf**
- **protected int len**
- **int read() throws java.io.IOException**
- **int read(byte[],int,int) throws java.io.IOException**

- ■ long skip(long) throws  
java.io.IOException
- ■ **class ZipEntry implements ZipConstants , Cloneable**
  - ■ ZipEntry(String)
  - ■ ZipEntry(ZipEntry)
  - ■ Object clone()
  - ■ final static int DEFLATED
  - ■ String getComment()
  - ■ long getCompressedSize()
  - ■ long getCrc()
  - ■ byte[] getExtra()
  - ■ int getMethod()
  - ■ String getName()
  - ■ long getSize()
  - ■ long getTime()
  - ■ int hashCode()
  - ■ boolean isDirectory()
  - ■ void setComment(String)
  - ■ void setCompressedSize(long)
  - ■ void setCrc(long)
  - ■ void setExtra(byte[])
  - ■ void setMethod(int)
  - ■ void setSize(long)
  - ■ void setTime(long)
  - ■ final static int STORED
  - ■ String toString()
- ■ **class ZipException extends java.io.IOException**
  - ■ ZipException()
  - ■ ZipException(String)
- ■ **class ZipFile implements ZipConstants**
  - ■ ZipFile(java.io.File) throws ZipException,  
java.io.IOException
  - ■ ZipFile(java.io.File,int) throws  
java.io.IOException
  - ■ ZipFile(String) throws  
java.io.IOException
  - ■ void close() throws java.io.IOException
  - ■ java.util.Enumeration entries()
  - ■ protected void finalize() throws  
java.io.IOException
  - ■ ZipEntry getEntry(String)
  - ■ java.io.InputStream  
getInputStream(ZipEntry) throws  
java.io.IOException
  - ■ String getName()
  - ■ final static int OPEN\_DELETE
  - ■ final static int OPEN\_READ
  - ■ int size()
- ■ **class ZipInputStream extendsInflaterInputStream implements ZipConstants**
  - ■ ZipInputStream(java.io.InputStream)
  - ■ int available() throws java.io.IOException
  - ■ void close() throws java.io.IOException
  - ■ void closeEntry() throws  
java.io.IOException
  - ■ protected ZipEntry  
createZipEntry(String)
  - ■ ZipEntry getNextEntry() throws  
java.io.IOException
  - ■ int read(byte[],int,int) throws  
java.io.IOException
  - ■ long skip(long) throws  
java.io.IOException
- ■ **class ZipOutputStream extends DeflaterOutputStream implements ZipConstants**
  - ■ ZipOutputStream(java.io.OutputStream)
  - ■ void close() throws java.io.IOException
  - ■ void closeEntry() throws  
java.io.IOException
  - ■ final static int DEFLATED
  - ■ void finish() throws java.io.IOException
  - ■ void putNextEntry(ZipEntry) throws  
java.io.IOException
  - ■ void setComment(String)
  - ■ void setLevel(int)
  - ■ void setMethod(int)
  - ■ final static int STORED
  - ■ void write(byte[],int,int) throws  
java.io.IOException

## 999.3.17

## javax.microedition.io

- ■ **package javax.microedition.io**
- ■ **interface Connection**
  - ■ abstract void close() throws  
java.io.IOException
- ■ **class ConnectionNotFoundException extends java.io.IOException**
  - ■ ConnectionNotFoundException()
  - ■ ConnectionNotFoundException(String)
- ■ **class Connector**
  - ■ static Connection open(String) throws  
java.io.IOException
  - ■ static Connection open(String,int)  
throws java.io.IOException
  - ■ static Connection open(String,int,  
boolean) throws java.io.IOException
  - ■ static java.io.DataInputStream  
openDataInputStream(String) throws  
java.io.IOException
  - ■ static java.io.DataOutputStream  
openDataOutputStream(String) throws  
java.io.IOException
  - ■ static java.io.InputStream  
openInputStream(String) throws  
java.io.IOException
  - ■ static java.io.OutputStream  
openOutputStream(String) throws  
java.io.IOException
  - ■ final static int READ
  - ■ final static int READ\_WRITE
  - ■ final static int WRITE
- ■ **interface ContentConnection extends StreamConnection**
  - ■ abstract String getEncoding()
  - ■ abstract long getLength()
  - ■ abstract String getType()

- **interface Datagram extends java.io.DataInput , java.io.DataOutput**
- abstract String getAddress()
- abstract byte[] getData()
- abstract int getLength()
- abstract int getOffset()
- abstract void reset()
- abstract void setAddress(String) throws java.io.IOException
- abstract void setAddress(Datagram)
- abstract void setData(byte[],int,int)
- abstract void setLength(int)
- **interface DatagramConnection extends Connection**
- abstract int getMaximumLength() throws java.io.IOException
- abstract int getNominalLength() throws java.io.IOException
- abstract Datagram newDatagram(byte[], int) throws java.io.IOException
- abstract Datagram newDatagram(byte[], int,String) throws java.io.IOException
- abstract Datagram newDatagram(int) throws java.io.IOException
- abstract Datagram newDatagram(int, String) throws java.io.IOException
- abstract void receive(Datagram) throws java.io.IOException
- abstract void send(Datagram) throws java.io.IOException
- **interface HttpConnection extends ContentConnection**
- final static String GET
- abstract long getDate() throws java.io.IOException
- abstract long getExpiration() throws java.io.IOException
- abstract String getFile()
- abstract String getHeaderField(int) throws java.io.IOException
- abstract String getHeaderField(String) throws java.io.IOException
- abstract long getHeaderFieldDate(String, long) throws java.io.IOException
- abstract int getHeaderFieldInt(String,int) throws java.io.IOException
- abstract String getHeaderFieldKey(int) throws java.io.IOException
- abstract String getHost()
- abstract long getLastModified() throws java.io.IOException
- abstract int getPort()
- abstract String getProtocol()
- abstract String getQuery()
- abstract String getRef()
- abstract String getRequestMethod()
- abstract String getRequestProperty(String)
- abstract int getResponseCode() throws java.io.IOException
- abstract String getResponseMessage() throws java.io.IOException
- abstract String getURL()
- final static String HEAD
- final static int HTTP\_ACCEPTED
- final static int HTTP\_BAD\_GATEWAY
- final static int HTTP\_BAD\_METHOD
- final static int HTTP\_BAD\_REQUEST
- final static int HTTP\_CLIENT\_TIMEOUT
- final static int HTTP\_CONFLICT
- final static int HTTP\_CREATED
- final static int HTTP\_ENTITY\_TOO\_LARGE
- **interface InputConnection extends Connection**
- abstract java.io.DataInputStream openDataInputStream() throws java.io.IOException
- abstract java.io.InputStream openInputStream() throws java.io.IOException
- **interface OutputConnection extends Connection**
- abstract java.io.DataOutputStream openDataOutputStream() throws java.io.IOException
- abstract java.io.OutputStream openOutputStream() throws java.io.IOException
- **interface StreamConnection extends InputConnection , OutputConnection**
- **interface StreamConnectionNotifier extends Connection**
- abstract StreamConnection acceptAndOpen() throws java.io.IOException
- final static int HTTP\_EXPECT\_FAILED
- final static int HTTP\_FORBIDDEN
- final static int HTTP\_GATEWAY\_TIMEOUT
- final static int HTTP\_GONE
- final static int HTTP\_INTERNAL\_ERROR
- final static int HTTP\_LENGTH\_REQUIRED
- final static int HTTP\_MOVED\_PERM
- final static int HTTP\_MOVED\_TEMP
- final static int HTTP\_MULT\_CHOICE
- final static int HTTP\_NO\_CONTENT
- final static int HTTP\_NOT\_ACCEPTABLE
- final static int HTTP\_NOT\_AUTHENTICATED
- final static int HTTP\_NOT\_FOUND
- final static int HTTP\_NOT\_IMPLEMENTED
- final static int HTTP\_NOT\_MODIFIED
- final static int HTTP\_OK
- final static int HTTP\_PARTIAL
- final static int HTTP\_PAYMENT\_REQUIRED
- final static int HTTP\_PRECON\_FAILED
- final static int HTTP\_PROXY\_AUTH
- final static int HTTP\_REQ\_TOO\_LONG
- final static int HTTP\_RESET
- final static int HTTP\_SEE\_OTHER
- final static int HTTP\_TEMP\_REDIRECT
- final static int HTTP\_UNAUTHORIZED
- final static int HTTP\_UNAVAILABLE
- final static int HTTP\_UNSUPPORTED\_RANGE
- final static int HTTP\_UNSUPPORTED\_TYPE
- final static int HTTP\_USE\_PROXY
- final static int HTTP\_VERSION
- final static String POST
- abstract void setRequestMethod(String) throws java.io.IOException
- abstract void setRequestProperty(String, String) throws java.io.IOException

999.4

Changes

999.4.1

Added Classes

|                                         |                                                 |
|-----------------------------------------|-------------------------------------------------|
| java.lang.InheritableThreadLocal        | java.security.SecureClassLoader                 |
| java.lang.ThreadLocal                   | java.security.SignatureException                |
| java.net.URLClassLoader                 | java.security.cert.Certificate.CertificateRep   |
| java.security.GeneralSecurityException  | java.security.cert.CertificateEncodingException |
| java.security.Guard                     | Exception                                       |
| java.security.GuardedObject             | java.security.cert.CertificateException         |
| java.security.InvalidKeyException       | java.util.EmptyStackException                   |
| java.security.InvalidParameterException | java.util.HashMap                               |
| java.security.Key                       | java.util.HashSet                               |
| java.security.KeyException              | java.util.LinkedList                            |
| java.security.NoSuchAlgorithmException  | java.util.Stack                                 |
| java.security.NoSuchProviderException   | java.util.TreeMap                               |
| java.security.Provider                  | java.util.TreeSet                               |
| java.security.PublicKey                 |                                                 |

999.4.2

Updated Classes

java.security.Permission updated to also implement java.security.Guard

999.4.3

Added Methods

|                                                                                                                                                            |                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| <b>java.io.DataInputStream</b><br>readUTF(java.io.DataInput)                                                                                               |                                                                                                        |
| <b>java.io.File</b><br>File[] listRoots()<br>File getParentFile()                                                                                          |                                                                                                        |
| <b>java.lang.Character</b><br>boolean isLetterOrDigit(char)                                                                                                | boolean setLastModified()Z<br>File[] listFiles()                                                       |
| <b>java.lang.Class</b><br>Object[] getSigners()                                                                                                            |                                                                                                        |
| <b>java.lang.ClassLoader</b><br>void setSigners(Class, Object[])                                                                                           |                                                                                                        |
| <b>java.lang.Double</b><br>boolean isInfinite()                                                                                                            | boolean isNaN()                                                                                        |
| <b>java.lang.Float</b><br>boolean isInfinite()                                                                                                             | boolean isNaN()                                                                                        |
| <b>java.lang.Integer</b><br>String toOctalString(int)<br>String toString(int, int)                                                                         | Integer valueOf(String)                                                                                |
| <b>java.lang.Long</b><br>String toString(long, int)                                                                                                        |                                                                                                        |
| <b>java.lang.String</b><br>String(StringBuffer)<br>String toLowerCase(Locale)<br>String toUpperCase(Locale)                                                | String valueOf(char[])<br>String valueOf(char[], int, int)                                             |
| <b>java.lang.Thread</b><br>int activeCount()<br>ClassLoader getContextClassLoader()                                                                        | void setContextClassLoader(ClassLoader)<br>String getLocalizedMessage()                                |
| <b>java.security.CodeSource</b><br>Certificate[] getCertificates()                                                                                         |                                                                                                        |
| <b>java.security.Permission</b><br>void checkGuard(Object)                                                                                                 |                                                                                                        |
| <b>java.security.Security</b><br>int addProvider(Provider)<br>Provider getProvider(String)<br>Provider[] getProviders()<br>Provider[] getProviders(String) | Provider[] getProviders(Map)<br>int insertProviderAt(Provider, int)<br>void removeProvider(String)     |
| <b>java.security.cert.Certificate</b><br>boolean equals(Object)<br>byte[] getEncoded()<br>PublicKey getPublicKey()<br>String getType()<br>int hashCode()   | String toString()<br>void verify(PublicKey)<br>void verify(PublicKey, String)<br>Object writeReplace() |

|                                                                                                                                                                                                                                                             |                                                                                                                                                                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>java.util.Calendar</b><br>Calendar(TimeZone,Locale)<br>Locale[] getAvailableLocales()<br>Calendar getInstance(Locale)                                                                                                                                    | Calendar<br>getInstance(TimeZone,Locale)                                                                                                                                          |
| <b>java.util.GregorianCalendar</b><br>GregorianCalendar(Locale)                                                                                                                                                                                             | GregorianCalendar(TimeZone,Locale)                                                                                                                                                |
| <b>java.util.Locale</b><br>Locale[] getAvailableLocales()<br>String getDisplayCountry()<br>String getDisplayCountry(Locale)<br>String getDisplayLanguage()<br>String getDisplayLanguage(Locale)<br>String getDisplayName()<br>String getDisplayName(Locale) | String getDisplayVariant()<br>String getDisplayVariant(Locale)<br>String getISO3Country()<br>String getISO3Language()<br>String[] getISOCountries()<br>String[] getISOLanguages() |
| <b>java.util.Properties</b><br>Object setProperty(String,String)                                                                                                                                                                                            |                                                                                                                                                                                   |
| <b>java.util.SimpleTimeZone</b><br>int getDSTSavings()                                                                                                                                                                                                      |                                                                                                                                                                                   |

# 999.5      References

[69]    *The Java Virtual Machine Specification*  
Tim Lindholm and Frank Yellin, Addison Wesley, ISBN 0-201-63452-X

[70]    *Downloadable Execution Environments*  
<http://www.osgi.org/download>

[71]    *J2ME, Java 2 Micro Edition*  
<http://java.sun.com/j2me>

[72]    *CDC, Connected Device Configuration*  
<http://java.sun.com/products/cdc>

[73]    *CLDC, Connected Limited Device Configuration*  
<http://java.sun.com/products/cldc>

[74]    *Foundation Profile*  
<http://java.sun.com/products/foundation>. This external specification is ©  
Copyright 2000 Sun Microsystems, Inc.







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