OSGi Service Platform Mobile Specification

The OSGi Alliance

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1 Introduction

The OSGi™ Alliance was founded in March 1999. Its mission is to create open specifications for the network delivery of managed services to local networks and devices. The OSGi organization is the leading standard for next-generation Internet services to homes, cars, small offices, and other environments.

The OSGi service platform specification delivers an open, common architecture for service providers, developers, software vendors, gateway operators and equipment vendors to develop, deploy and manage services in a coordinated fashion. It enables an entirely new category of smart devices due to its flexible and managed deployment of services. The primary targets for the OSGi specifications are set top boxes, service gateways, cable modems, consumer electronics, PCs, industrial computers, cars and more. These devices that implement the OSGi specifications will enable service providers like telcos, cable operators, utilities, and others to deliver differentiated and valuable services over their networks.

This is the fourth release of the OSGi service platform specification developed by representatives from OSGi member companies. The OSGi Service Platform Release 4 mostly extends the existing APIs into new areas. The few modifications to existing APIs are backward compatible so that applications for previous releases should run unmodified on release 4 Frameworks. The built-in version management mechanisms allow bundles written for the new release to adapt to the old Framework implementations, if necessary.

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 [2] *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 1.1 Packages and versions

Item	Package	Version	Opt
Framework	org.osgi.framework	Version 1.3	
Package Admin Service Specification	org.osgi.service.packageadmin	Version 1.2	
Conditional Permission Admin Specification	org.osgi.service.condpermissionadmin	Version 1.0	Yes
Permission Admin Service Specification	org.osgi.service.permissionadmin	Version 1.2	
3 Mobile Management Tree		Version 1.0	
101 Log Service Specification	org.osgi.service.log	Version 1.3	
104 Configuration Admin Service Specification	org.osgi.service.cm	Version 1.2	
105 Metatype Service Specification	org.osgi.service.metatype	Version 1.1	
109 IO Connector Service Specification	org.osgi.service.io	Version 1.0	Yes
112 Declarative Services Specification	org.osgi.service.component	Version 1.0	
113 Event Admin Service Specification	org.osgi.service.event	Version 1.1	
114 Deployment Admin Specification	org.osgi.service.deploymentadmin org.osgi.service.deploymentadmin.spi	Version 1.0	
115 Auto Configuration Specification		Version 1.0	
116 Application Admin Service Specification	org.osgi.service.application	Version 1.0	

Table 1.1 Packages and versions

Item	Package	Version	Opt
117 DMT Admin Service Specification	info.dmtree info.dmtree.spi info.dmtree.security info.dmtree.notification info.dmtree.notification.spi info.dmtree.registry	Version 1.0	Yes
118 Mobile Conditions Specification	org.osgi.util.gsm org.osgi.util.mobile	Version 1.0	Yes
119 Monitor Admin Service Specification	org.osgi.service.monitor	Version 1.0	Yes
120 Foreign Application Access Specification	org.osgi.application	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	Yes

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

1.3 Non Functional Requirements

1.3.1 Framework Optionality

The OSGi Release 4 Core specification on which the Mobile Specifications are based defines a number of aspects as optional:

- Fragments
- Require-Bundle

This specification inherits the optionality. Compliant implementations are not required to implement these optionalities, however, when they do, they must conform strictly to the Core specification. This implies that bundle developers cannot rely on the presence of these features in a compliant device. Bundles that use any of the optional features must not be allowed to install on a device that does not implement these features.

1.3.2 Security Formats and Algorithms

Required certificate formats:

- [3] *X.509 Certificates*

Required Digest Algorithms:

- [4] *Secure Hash Algorithm 1*
- [5] *RFC 1321 The MD5 Message-Digest Algorithm*

Required Signing Algorithm

- [6] *RSA*

1.3.3 Device Management

Device Management is based on concepts in [9] *Open Mobile Alliance*. The following limits apply.

The Mobile Management tree is an optional aspect of this specification because the Dmt Admin service is optional.

- Node name lengths of 32 bytes or more must be supported. This length is defined upon the unescaped, UTF-8 encoded name.
- URI lengths of 255 bytes or more must be supported. This length is based on the same encoding as previous bullet.
- The minimum number of segments that must be supported in a URI is 16.

1.3.4 Execution Environment

This specification requires a Profile that meets the [8] *OSGi Minimum Execution Environment Version 1.1*.

1.3.5 Configuration Admin

Property key names used in the Configuration Admin service must be less or equal than 32 bytes when encoded in UTF-8 to prevent from being mangled in the DMT Admin.

1.4 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 Platform, Release 4*
http:/www.osgi.org/download

[3] *X.509 Certificates*
http://www.ietf.org/rfc/rfc2459.txt

[4] *Secure Hash Algorithm 1*
http://csrc.nist.gov/publications/fips/fips180-2/fips180-2withchangenotice.pdf

[5] *RFC 1321 The MD5 Message-Digest Algorithm*
http://www.ietf.org/rfc/rfc1321.txt

[6] *RSA*
http://www.ietf.org/rfc/rfc2313.txt which is superseded by
http://www.ietf.org/rfc/rfc2437.txt

[7] *Public Key Crypography Standard #7*
http://www.rsasecurity.com/rsalabs/node.asp?id=2129

[8] *OSGi Minimum Execution Environment Version 1.1*
http:/www.osgi.org/download

[9] *Open Mobile Alliance*
http://www.openmobilealliance.org/release_program/index.html

2 JSR Interactions

Version 1.0

2.1 Introduction

This chapter discusses issues that may arise when JSRs are used in an OSGi environment.

2.2 JSR 211 Content Handling

The [1] *JSR 211 Content Handler API* (CHAPI) allows applications and other similar entities with a lifecycle to act as content handlers. In the context of OSGi, these entities are OSGi bundles. The following subsections define in more detail how JSR 211 Content Handler API can be implemented on OSGi and how bundles can act as content handlers.

2.2.1 Content Handler API

The Content Handler API is an optional package for the J2ME platform. It allows applications and other entities to register themselves as content handlers and to invoke other content handlers. A content handler is an entity with a lifecycle (typically an application) that has registered itself to be invoked through the API. The registered entities typically handle some content, but this is not required. A lifecycle entity can register itself only for the purpose of being invoked by other entities and applications, without needing to handle any content. Invocations can be based on content URL, content type, or content handler ID. Arguments may also be passed to a content handler, and the content handler can return results and a status.

The CHAPI specification consists of a generic part and a platform-specific part. The generic part of the specification applies to all CHAPI implementations, whereas the platform-specific part needs to be specified for each Java platform that has its own concepts for application packaging and lifecycle primitives. The CHAPI defines the platform-specific part of the specification for Mobile Information Device Profile (MIDP), but leaves it undefined for other platforms. Consequently, a specification is needed for the platform specific parts of CHAPI on the OSGi platform.

The following subsections briefly define the platform-specific parts of a CHAPI implementation on the OSGi platform. Familiarity with the Content Handler API specification is assumed. This specification lists only the additional requirements and clarifications that are needed to implement the API in an interoperable way on the OSGi Service Platform.

2.2.2 Content Handler Identification

A Content Handler API implementation in the OSGi Service Platform must allow bundles to be registered as content handlers, by either static or dynamic means as defined by the Content Handler API.

Static registration manifest headers are the same as those defined in the package description of the Content Handler API. The dynamic registration parameters are as defined for method Registry.register(). The semantics of the class name parameter in both static and dynamic registrations, however, is defined for the OSGi Service Platform in the following manner.

When an OSGi bundle is registered as a content handler, it must define a service that has a service.pid service property and use the value of this PID as the class name parameter in the context of the Content Handler API.

Static registration of a service as a content handler must fail if the service.pid service property is undefined. Dynamic registration of a service as a content handler must fail if the service.pid service property passed in as a parameter does not represent a service that has been registered into the system.

This definition for the class name parameter semantics also applies to methods: Registry.getRegistry(), Registry.getServer() and Registry.unregister().

The static registration attributes are placed into the bundle's manifest file.

2.2.3 Content Handler Access Control

The Content Handler API includes a mechanism allowing content handlers to optionally limit their accessibility to a predefined list of invokers. This mechanism requires that the invokers can define a unique identifier for themselves. CHAPI defines that MIDlets can define this identifier using the attribute MIDlet-<n>-ID, where <n> refers to a specific MIDlet within the MIDlet suite JAR. Because this attribute is MIDP-specific, a corresponding way to identify OSGi bundles is needed.

As specified in the Content Handler API specification, a content handler can use the attribute MicroEdition-Handler-<n>-ID to identify itself for the purposes of access control. As this attribute is only applicable to content handlers, bundles that are not content handlers must use the Bundle-SymbolicName header as their identification.

2.2.4 Method Descriptions

Definitions of some Content Handler API methods also need tfurther clarification in an OSGi-based Content Handler API implementation. Below are descriptions of these methods and clarifications.

2.2.4.1 ContentHandler.getAppName()

A bundle acting as a content handler must define a service.name property that will contain the service name. This property will be used as the return value from this method.

2.2.4.2 ContentHandler.getAuthority()

The return value must be the subject of the signing certificate, if the bundle has been signed and the signature verification has been successful. Otherwise null must be returned.

2.2.4.3 ContentHandler.getID()

No relevant changes.

2.2.4.4 ContentHandler.getVersion()

A bundle acting as a content handler should define a service.version property that will contain the implementation version of the service. This property will be used as the return value from this method. If the service.version property is not defined, the implementation must return null.

2.2.4.5 Invocation.getID() and Invocation.getInvokingID()

No relevant changes.

2.2.4.6 Invocation.getInvokingAppName()

Return value is obtained in the same way as for *ContentHandler.getAppName()* on page 6.

2.2.4.7 Invocation.getInvokingAuthority()

No relevant changes.

2.2.4.8 Registry.getID() and Registry.getIDs()

No relevant changes.

2.2.4.9 Registry.getRegistry(), Registry.getServer(), Registry.register(), Registry.unregister()

No relevant changes.

2.3 References

[1] *JSR 211 Content Handler API*
http://www.jcp.org/en/jsr/detail?id=211

3 Mobile Management Tree

Version 1.0

3.1 Introduction

This section defines the Mobile Management Tree as it must be available on an OSGi Mobile Platform via the Dmt Admin service. The protocol used between the remote manager and the device is not specified, but it is expected that OMA DM will be the common protocol to manipulate this tree. Therefore, the objects defined in this chapter have only been evaluated against the OMA DM protocol, although the OMA DM protocol is optional for this specification.

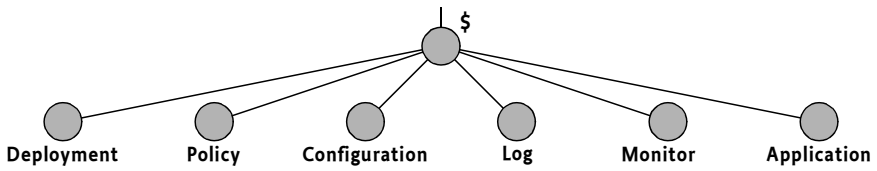
Concepts and terms used in this section are defined and explained in *DMT Admin Service Specification* on page 303.

The OSGi Mobile Management Tree is a relative tree. Devices can place the root of this tree anywhere in the Device Management Tree. In this specification, this relative location in the Device Management Tree is indicated with the $ sign. The root of the OSGi tree is set in the System property that must not change during runtime:

```
info.dmtree.osgi.root
```

The OSGi Mobile Management Tree consists of a number of distinct parts. The top level nodes of the sub-trees are depicted in Figure 3.1. The legend for this picture can be found in Figure 117.4 on page 308. Additionally, nodes that are created dynamically with a parametrized name are indicated with angular brackets (<>), for example <node_id>. Interior nodes use a bold type face. All dynamic nodes must use the name mangle method on the Dmt Admin service to ensure that the given name is compatible with the requirements of the tree implementation.

Figure 3.1 *Overall Tree*



These different sub-trees are discussed in the following paragraphs.

3.1.1 Legend

The pictures in this chapter follow the legend defined in Figure 117.4 on page 308. All nodes are described in a table format. This table format defines the following meta information:

- *Add* - An x indicates that the implementation must support creation of the given node by the management system.
- *Get* - An x indicates that the implementation must support retrieval of the properties of the given node (including the value).
- *Replace* - An x indicates that the implementation must support setting the value of the given node. Support for changing the other properties is optional. Note, that this column does not correspond to the Replace Access Type, which can be provided by an implementation even if the node value cannot be changed, for example in case it supports setting the Title property.
- *Delete* - An x indicates that the implementation must support deletion of the given node by the management system.
- *Exec* - An x indicates that the implementation must support the execute operation for the given node.
- *Type* – The `node` type for an interior `node`, or the data type for a leaf node. The data type is a combination of: `chr`, `int`, `float`, `date`, `time`, `bin`, `xml`, `bool`, `b64`.
- *Cardinality* – The range of occurrences of the given node. $*$ means infinite.
- *Scope* – The scope indicates the creation strategy. It can have the following values:
  - *P* – Permanent. A permanent node cannot be changed by the management system. It can, however, appear due to an internal device event, for example, the insertion of an accessory.
  - *D* – Dynamic. A node that must be created by the management system. Such a creation can then automatically create other nodes.
  - *A* – Automatic. A node that is created automatically by a managed object if a parent node is created.
  - - – Unknown, Used in optional extension point for vendor (implementation-specific) parameters. Vendor extensions must not be defined outside of one of these Ext sub-trees. The interior node creation depends on the implementation.

In many cases, actions take their parameters from nodes that are in the same context. They share a common parent or the context is provided by a subtree. This tree, which provides the context, is called the *context tree*.

3.2 Configuration Management Object

The Configuration Admin Service is responsible for:

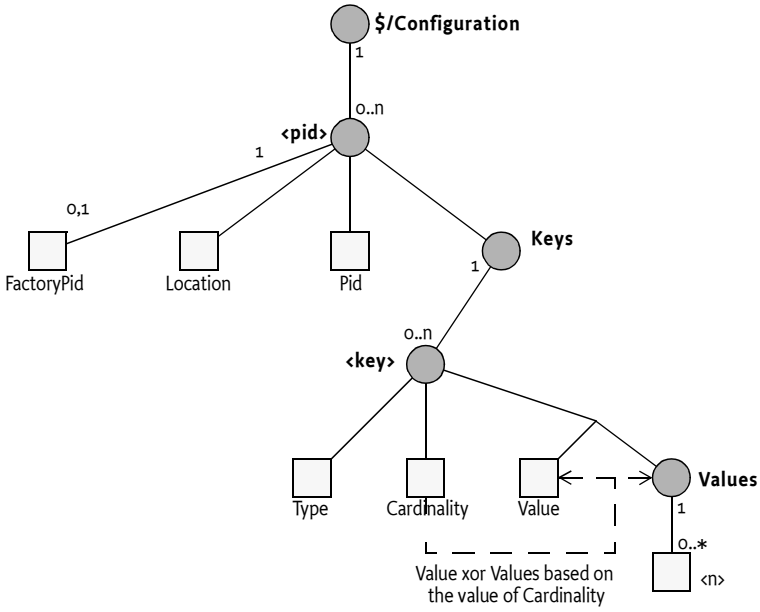
- Storing configuration information,

- Providing this information to bundles that need configuration information, and
- Notifying these bundles when their configuration changes.

The Configuration Management Object is responsible for mapping these functions to the Mobile Management Tree, except for the notifications. The Configuration Management Object implementation can be included in a separate bundle, or it can be included with the implementation of the Configuration Admin service.

The tree structure of *Configuration Admin Service Specification* on page 71 can be accessed from the $/Configuration sub-tree. Figure 3.2 depicts the structure of the Configuration Management Object sub-tree.

Figure 3.2 Configuration Management Object Tree



The Tree represents each Configuration object as a sub-tree under a node that has its PID as its name. This configuration node resides under the $/Configuration sub-tree.

The Configuration Management Object must support transactions because all changes to the $/Configuration tree must be done in an atomic session to keep the Configuration object consistent. Only atomic sessions can perform the required single update of all the configuration properties, as well as decide to make a factory or singleton configuration.

The length of the PID string should be shorter than the URI segment length limit defined for the given device. As the Configuration Admin specification does not contain these limitations for PIDs, it cannot always be guaranteed that the PID is a valid node name. The actual PID, therefore, must always be stored in the $/Configuration/<pid>/Pid node.

All nodes for the Configuration Management Object sub-tree are explained in Table 3.1.

Table 3.1 Configuration Admin sub-tree Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Configuration		x				node	1	P	Configuration Root node.
Configuration/**<pid>**	x	x		x		node	0..*	D	Interior node that represents the Configuration object. The name of this node is usually the mangled PID of the Configuration object.
Configuration/<pid>/**Location**	x	x				chr	1	D	Bundle location of the Configuration object.
Configuration/<pid>/**Pid**	x	x				chr	1	D	The actual PID as used by the Configuration Admin service. Always the Configuration object's PID, never a factory PID.
Configuration/<pid>/**FactoryPid**	x	x				chr	0,1	D	If this node is present, then the subtree is for a factory configuration. The value of this node is the PID of the corresponding Managed Service Factory.
Configuration/<pid>**/Keys**		x				node	1	A	Holds the key nodes that contain the values for the Configuration object.
Configuration/<pid>/Keys/**<key>**	x	x		x		node	0..*	D	A node with the name of a key. The node holds the value of an entry in the configuration Dictionary. This key must be shorter than the max defined node name length (see *Device Management* on page 4). The value is defined by its type, cardinality and value sub-nodes. The nodes of the <key> sub-tree are not automatic because the tree structure depends on the type of the value to be stored.
Configuration/<pid>/Keys/<key>/**Type**	x	x				chr	1	D	Type of the property. See *Configuration dictionary nodes* on page 13.
Configuration/<pid>/Keys/<key>/**Cardinality**	x	x				chr	1	D	Cardinality of the property. See *Configuration dictionary nodes* on page 13. The value is either: scalar, vector or array.

Table 3.1 Configuration Admin sub-tree Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Configuration/<pid>/Keys/<key>/**Value**	x	x	x			chr bin int bool float	0,1	D	Contains the value of a property in a leaf node (see *Configuration dictionary nodes* on page 13). This node is only present if the cardinality is scalar. It has chr format if there is no corresponding node type as defined in Table 3.2 on page 14.
Configuration/<pid>/Keys/<key>/**Values**	x	x				node	0,1	D	Interior node that contains the actual values. Children are leaf nodes (see *Configuration dictionary nodes* on page 13).This node is only present if the cardinality is vector or array.
Configuration/<pid>/Keys/<key>/Values/**<n>**	x	x	x	x		chr int bool float	0..*	D	A leaf node that contains a value which is defined by the <key>/Type node in this sub tree. The name must be an integer that is continuous for the parent tree.

3.2.1 Factory and Singleton Configurations

Both a factory configuration and a singleton configuration share the same basic structure, described in the previous section. The difference is that a factory configuration has a node for the $/Configuration/<pid>/FactoryPid URI.

Such a node can only be created, however, if the <pid> component of the URI is known ahead of time. For factories, it is not possible to know the component ahead of time, because the Configuration Admin service creates a unique PID whenever a new factory configuration is made. The interaction required between the initiator and the Configuration Admin service for this model was deemed too complex.

Therefore, the <pid> component of the URI must be chosen by the creator of the node and is treated as an alias. The Configuration Management Object must map this chosen PID to the PID that is generated by the Configuration Admin service. This mapping must be maintained as long as the node exists.

In this way, the PID of the factory configuration becomes a well-known name for the initiator without needing an additional protocol message exchange or variables in scripts. The actual PID is determined by the Configuration Management Object and is reflected in the Pid node.

3.2.2 Configuration dictionary nodes

The configuration Dictionary of a configuration target consists of key-value pairs. The configuration Dictionary is mapped to a sub-tree. The URI for a configuration item is the following:

$/Configuration/<pid>/Keys/<key>

For example, a portNumber property of a com.acme.fudd Configuration object can be found in the sub-tree under the following URI:

```
$/Configuration/com.acme.fudd/Keys/portNumber
```

Key nodes are interior nodes. Their type, cardinality, and value are represented as separated nodes. These sub-nodes are:

- *Type* contains the Java type name like java.lang.Float, char, etc.
- *Cardinality* – Defines if the value is a scalar, an array, or vector. It can take the following values:
  - *scalar* – For a simple, unstructured value, like a string or a byte[].
  - *array* – When the value is a Java array (but not byte[])
  - *vector* – When the value must be a Java Vector object.
- *Value* – A leaf node that only exists if the cardinality is scalar.
- *Values* – Exists if the cardinality is array or vector. The children of this node must be named with an integer that starts at zero for the first element, and increases by one with each additional element.

The actual value (Value node or Values child nodes) is mapped to a Dmt Data type if possible. If this mapping is not possible, the node must be a chr node and the Java class of the given type must be able to parse the value in a constructor.

For Dmt Type nodes, the mapping as defined in Table 3.2 must be used.

Table 3.2 *Dmt Types to Java Types mapping*

Dmt Type	Java Type	Notes
chr	java.lang.String	
int	java.lang.Integer, int	Primitive types only in arrays
bool	java.lang.Boolean, boolean	Primitive types only in arrays
float	java.lang.Float, float	Primitive types only in arrays
bin	byte[]	
chr	Other	String must contain the value in string form.

The OMA DM time, b64 and xml formats have no representation in the Configuration Dictionary.

3.2.3 Restrictions

The specified DMT structure is very flexible, and permits the representation of Configuration objects that are not considered valid according to the Configuration Admin Service specification. Following is a list of restrictions and rules that should be obeyed in order to maintain valid Configuration objects. If these rules are violated, the Configuration Management Object must throw a Dmt Exception.

- Vectors cannot store primitive types (long, int, short, char, byte, boolean, double and float); therefore, they must not be used in sub-trees representing a Vector object.
- Java arrays and vectors are indexed from zero to some number continuously. If an index is missing, the array or vector is in an inconsistent state. When deleting elements (an unlikely but possible use case) care

must be taken to maintain the continuous indexing of elements at the end of the modification session.
- The node names in the Dmt Admin service are case-sensitive. In a configuration dictionary, however, the keys are searched without regard to case. Therefore, the node names in the DMT representation of a configuration dictionary must be different even if compared without regard to case.
- Nodes in the $/Configuration sub-tree support the Add, Get, Replace and Delete commands, controlled by the ACL of the node. These nodes do not support the exec command.
- Modification of more than one entry under the same <pid> node must be done atomically. In other words, the whole dictionary is updated in one step. In OMA DM, this concept corresponds to the atomic operation.

3.3 Log Management Object

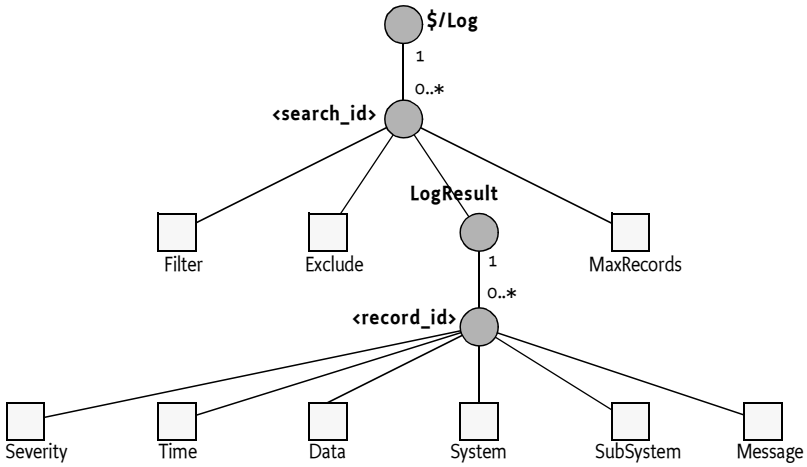
This section describes how log information is made available in the Mobile Management Tree. Typically, a Mobile Management Tree user is interested in a subset of the log records, for example, the highest severity entries originating from a specific application within the last 24 hours. Doing the filtering on the server side is not an option because of the high bandwidth required to transfer all the records. Therefore, the remote manager must have means to issue log search requests and receive only the log records in which it is interested. The standard OSGi Log Reader service (see *Log Service Specification* on page 59), does not provide filtering, it simply returns the full list of available log records.

The Log Management Object is responsible for mapping this repository of log records to the Mobile Management Tree. The initiator must create a search node with the appropriate parameters, and then read back the result from an automatically created node.

The Log Management Object does not have to support transactions.

Log searches can be initiated using the $/Log sub-tree. This sub-tree is depicted in Figure 3.3.

Figure 3.3 Mobile Management Tree for Log Management Object



The log sub-tree nodes are defined in the following table:

Table 3.3 Log Management Object Tree

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Log		x				node	1	P	Log Root node.
Log/**<search_id>**	x	x		x		node	0..*	D	Represents a log search request. The name of the node is a unique ID generated by the initiator.

Log/<search_id>/**Filter**		x	x			chr	1	A	Contains the filtering expression. The result must include only those log entries that satisfy the specified condition. The filter should be given in the OSGi Filter format. The filter can contain conditions with the node names below the LogResult node. For example:
									`(&(Severity>=2)`
									`(Time>=20040720T194223Z))`
									The empty string indicates that no filtering must be done. An empty string is the default value for this node.

Table 3.3 Log Management Object Tree

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Log/<search_id>/**Exclude**		x	x			chr	1	A	A comma-separated list of log entry nodes. All node names that are specified below the `LogResult` node can be used. If specified, the listed node names must not be included in the search result. The filter expression may contain (and filtering should be done against) conditions for a node even if it is added to the exclude list. For example: `Severity, Data` If the `Exclude` node is empty, all log entry nodes must be included in the search result, which is the default value for this node.
Log/<search_id>/**MaxRecords**		x	x			int	1	A	The maximum number of log records to be included in the search result. The default value for this node is zero, which means no limit.
Log/<search_id>/**LogResult**		x				node	1	A	All data related to log search requests is stored under the `LogResult` node. The children of this node are only generated when this sub-tree is first accessed, based on the actual log request parameters.
Log/<search_id>/LogResult/**<record_id>**		x				node	0..*	A	A device-generated unique identifier of the log record.
Log/<search_id>/LogResult/<record_id>/**Time**		x				chr	0,1	A	The value is the UTC based date and time of the creation of the log entry in basic representation, complete format as defined by ISO-8601 with the pattern `yyyymmddThhmmssZ`. For example: `20040720T221011Z`

Log/<search_id>/LogResult/<record_id>/**Severity**		x				int	0,1	A	The severity level of the log entry. The value is the same as the Log Service level values:
									`LOG_ERROR 1`
									`LOG_WARNING 2`
									`LOG_INFO 3`
									`LOG_DEBUG 4`
									Other values are possible because the Log Service allows custom levels.

Table 3.3 Log Management Object Tree

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Log/<search_id>/LogResult/<record_id>/**System**		x				chr	0,1	A	The name of the large-scale functional unit that generated the entry, for example, the ID of the originator bundle.
Log/<search_id>/LogResult/<record_id>/**SubSystem**		x				chr	0,1	A	The name of a related service.
Log/<search_id>/LogResult/<record_id>/**Message**		x				chr	0,1	A	Textual, human-readable description of the log entry.
Log/<search_id>/LogResult/<record_id>/**Data**		x				chr	0,1	A	Supplementary data for the log entry, it can be empty. The content is log-entry specific. Normally, this attribute should contain exception information associated with the log entry, if any. The attribute should also contain the name of the exception class, the message, and the stack trace associated with the Exception object.

3.3.1 Using log search

All data related to a log search request is stored in the log sub-tree under the following URI:

```
$/Log/<search_id>
```

where <search_id> is a unique identifier of the search request, given by the initiator when it creates the node representing the search request.

To prepare a log search, the client should first create a new node in DMT in the $/Log sub-tree and optionally fill in the following nodes: Filter, Exclude, and MaxRecord.

At any moment, the initiator can start reading the automatically created LogResult sub-tree. This node must contain as its children only the log records that match the criteria of the context tree at the moment of the first read, in other words, the selection must be frozen at the time the first node is read.

The sub-tree must only contain the leaf nodes that are not barred by the Excluded node.

The <search_id> node can be deleted by the management server at its convenience. The node can therefore be used as a prepared script.

The Log Management Object can delete the <search_id> after an implementation-defined time that should allow ample time for reading the results.

3.4 Monitor Management Object

This section describes how the monitor-related features are made available in the Mobile Management Tree.

The OMA Device Management work group defined a management object structure for *Traps*, which is event based reporting of faults and performance data (see the Trap-MO documents in [6] *OMA DM Draft Trap-MO 1.3*). The structure defined on OMA can be used without modifications in OSGi to represent monitoring data in the Mobile Management Tree. The Trap Management Object is not described in this document, refer to [6] *OMA DM Draft Trap-MO 1.3* for the definition.

Some features are available only to the user of the Monitor Admin Service API, not to a Mobile Management Tree user. The API allows specification of a given number of measurements to be made. The Mobile Management Tree user has to explicitly stop a measurement job, otherwise it will never expire. In the OMA Trap MO, there is no `count` parameter for periodic measurement jobs, only the frequency can be set (i.e. all jobs started using the DMT have a `count` value of zero). In this way, the job is reported as *running* and also keeps sending events until it is explicitly stopped, either through the tree or from the API.

A monitorable service is identified by its `service_pid`. The Status Variables provided by the Monitorable service are stored in the Mobile Management Tree under the node:

```
$/Monitor/<service_pid>/<status_variable_name>
```

This is an interior node which has a substructure from the `<X>*` node defined as the root node in the Trap MO documents. The sub-tree holds information about the collection method, the reporting schedule, and the current value of the Status Variable.

Figure 3.4 Trap MO

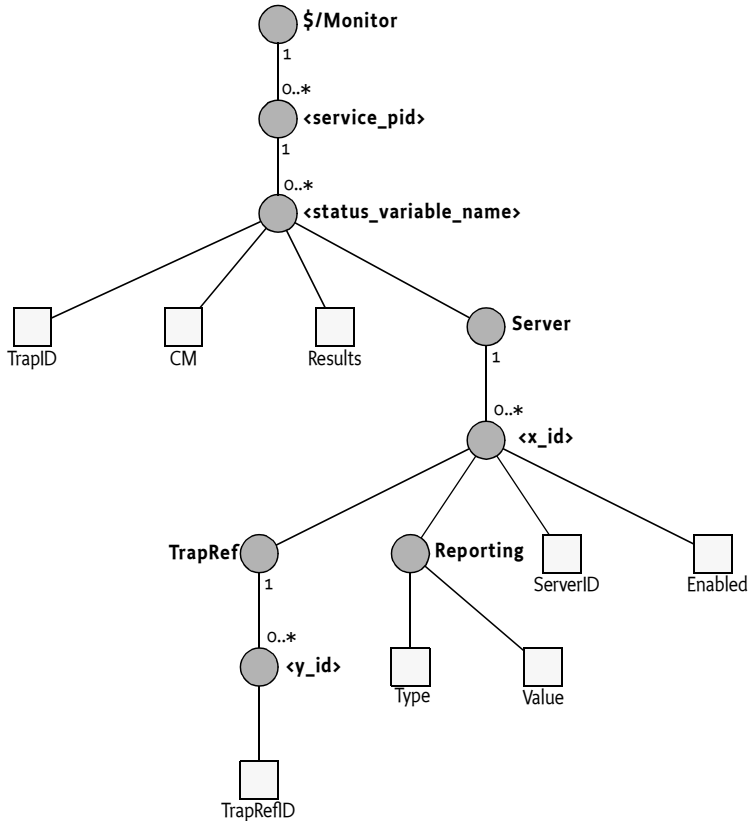


Table 3.4 Monitor Management Object Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Monitor		x				node	1	P	Monitor Root node.
Monitor/**<service_pid>**		x				node	0..*	P	A Monitorable service. The name of the node is the PID of the Monitorable service.
Monitor/<serivce_pid>/ **<status_variable_name>**		x				node	0..*	P	A Status Variable published by a Monitorable service. The name of the node is the ID of the Status Variable.
Monitor/<serivce_pid>/ <status_variable_name>/ **TrapID**		x				chr	1	P	Contains the full name of the Status Variable in the form of: <service_pid>/ <status_variable_name>

Table 3.4 Monitor Management Object Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Monitor/<serivce_pid>/<status_variable_name>/**CM**		x				chr	1	P	Contains the collection method that describes how the measured data is collected for a particular Status Variable.
Monitor/<serivce_pid>/<status_variable_name>/**Results**		x				chr int float bool	1	P	Stores the measurement data provided by the Status Variable. The type of the node corresponds to the type of the Status Variable.
Monitor/<serivce_pid>/<status_variable_name>/**Server**		x				node	1	P	This interior node acts as a placeholder for all the management servers to which the alerts containing the measured data would be sent.
Monitor/<serivce_pid>/<status_variable_name>/Server/**<x_id>**	x	x		x		node	0..*	D	Defines a Monitoring job for a management server requesting alerts with the measurement data.
Monitor/<serivce_pid>/<status_variable_name>/Server/<x_id>/**ServerID**		x	x			chr	1	A	Identifies the management server to which the alerts should be sent (the principal). The default value for this node is the name of the parent node (shown as <x_id> here).
Monitor/<serivce_pid>/<status_variable_name>/Server/<x_id>r/**Enabled**		x	x			bool	1	A	Indicates if the Monitoring job defined in this sub-tree is enabled or disabled. If the job is disabled, no alerts are sent to the management server. The default value for this node is false, that is, the job is disabled until explicitly enabled.
Monitor/<serivce_pid>/<status_variable_name>/Server/<x_id>r/**Reporting**		x				node	1	A	Acts as a placeholder for nodes that indicate when the data related to the Status Variable is reported back to the management server. The data reporting is either Time- based or Event-based.
Monitor/<serivce_pid>/<status_variable_name>/Server/<x_id>r/Reporting/**Type**		x	x			chr	1	A	Indicates if the data reporting is Time- or Event-based. The string TM indicates Time-based reporting, alerts are sent periodically. The Value node specifies number of seconds between alerts. The string EV indicates Event-based reporting, alerts are triggered by the changes of the variable. In this case the Value node specifies the number of times the variable changes between sending alerts.

Table 3.4 Monitor Management Object Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Monitor/<serivce_pid>/<status_variable_name>/Server/<x_id>r/Reporting/**Value**		x	x			int	1	A	The Value node's semantics depend on the Type node. If it is zero, alerts must be sent at each change of the monitored Status Variable (independently from the value of the Type node). If it is greater than 0, it defines the number of seconds between alerts for the TM Type, or the number of changes of the monitored Status Variable between alerts for the EV Type.
Monitor/<serivce_pid>/<status_variable_name>/Server/<x_id>r/**TrapRef**		x				node	1	A	Acts as a placeholder for nodes that identify other Status Variables (uniquely identified by their respective TrapIDs) whose results must be reported along with the results of this Status Variable.
Monitor/<serivce_pid>/<status_variable_name>/Server/<x_id>r/TrapRef/**<y_id>**	x	x		x		node	0..*	D	Acts as a placeholder for a TrapRefID node.
Monitor/<serivce_pid>/<status_variable_name>/Server/<x_id>r/TrapRef/<y_id>**/<TrapRefID**		x	x			chr	1	A	Specifies another Status Variable (identified by its TrapID), the measurement data of which must also be sent back to the server whenever an alert is sent.

3.4.1 Result node format

The Trap MO does not define how the Status Variables should be stored in the Results node, but it prohibits the use of a tree representation. The Trap MO allows only a single node of any allowed OMA DM format.

The Status Variables only support the following types:

- *float* – Mapped to DmtData FORMAT_FLOAT
- *String* – Mapped to DmtData FORMAT_STRING
- *int* – Mapped to DmtData FORMAT_INTEGER
- *boolean* – Mapped to DmtData FORMAT_BOOL

3.4.2 Alert

The Trap MO mandates that an alert must be sent to the initiator when a Status Variable is updated or when the predefined sampling time expires. This alert must have alert code 1226.

It must carry one Dmt Alert Item with the new Status Variable value in its Alert Item element. The type of the alert item must be x-oma-trap:<service_id>/<sv_name>.

An Alert needs the following set of parameters:

- *code* – Defined as 1226
- *correlator ID* – Not used, as it is not triggered by an EXEC command

Each involved Status Variable must be included as a Dmt Alert Item. Such items must contain the following information:

- *source* – $/Monitor/<Monitorable ID>/<Status Variable ID>
- *type* – x-oma-trap:<Monitorable ID>/<Status Variable ID>
- *format* – xml
- *mark* – not used
- *data* – A DmtData object with the value.

3.5 Application Model Management Object

This section describes how the features listed in the *Application Admin Service Specification* on page 269 are made available to a Mobile Management Tree user. The entity responsible for this mapping is the Application Model Management Object.

3.5.1 Applications Descriptors

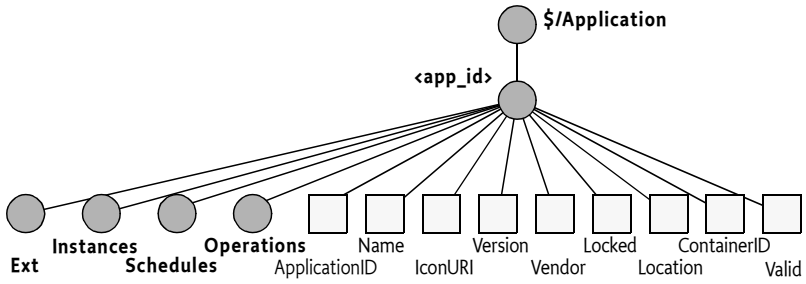
When an Application Container can provide an application, it registers an Application Descriptor service. The Application Descriptor service is unregistered when the application is uninstalled or is no longer available for other reasons. This model is described in *Application Admin Service Specification* on page 269.

Each installed application is represented in the Mobile Management Tree under the following URI:

```
$/Application/<app_id>
```

where <app_id> comes from the corresponding Application Descriptor service's service.pid service property.

Figure 3.5 Application Management Tree



The nodes are defined in the following table:

Table 3.5 Application Descriptor Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Application		x				node	1	P	Application Model root node.
Application/**<app_id>**		x				node	0..*	P	Representation of an Application Descriptor service. The node name must be the service.pid service property of the corresponding Application Descriptor service. This node name must be mangled to the device constraints.
Application/<app_id>/**Valid**		x				bool	1	P	Indicates whether the application is valid. The application is valid if it still has its ApplicationDescriptor service registered. If its value is false then there are some existing schedules of the application. In that case, any access to any other node than Valid, ApplicationId, or Schedules must return an empty value for its given type. Using EXEC on the appropriate nodes must throw a Dmt Exception. When the schedules are completely removed, the whole $/Application/<app_id> subtree will also be removed.
Application/<app_id>/**Name**		x				chr	1	P	The name of the application localized according to the default locale. This value matches the application.name service property of the application descriptor.
Application/<app_id>/**ApplicationID**		x				chr	1	P	Unmangled version of the service.pid property of the corresponding application descriptor
Application/<app_id>/**IconURI**		x				chr	1	P	The URI of an application icon localized according to the default locale. This value matches the application.icon service property of the Application Descriptor service.
Application/<app_id>/**Vendor**		x				chr	0,1	P	The vendor of the application. This value matches the service.vendor service property of the Application Descriptor service.
Application/<app_id>/**Version**		x				chr	0,1	P	The version of the application. This value matches the application.version service property of the Application Descriptor service.

Table 3.5 Application Descriptor Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Application/<app_id>/**Locked**		x				bool	1	P	Indicates whether the application is *locked*. The value matches the application.locked service property of the corresponding application descriptor. See *Locking and Unlocking* on page 29 for more information about locking.
Application/<app_id>/**ContainerID**		x				chr	1	P	The identifier of the container registering the corresponding Application Descriptor service. The value of this node matches the application.container service property.
Application/<app_id>/**Location**		x				chr	1	P	The identifier of the package (for example, Deployment Package) that contains the corresponding application. The value is provided by the container in the application.location service property of the Application Descriptor service.
Application/<app_id>/**Ext**		x				node	0,1	P	Application model and container specific properties can be placed under the Ext node.
Application/<app_id>/**Instances**		x				node	1	P	Contains the currently existing instances of the context application. See *Application Instances* on page 30.
Application/<app_id>/**Operations**		x				node	1	P	Contains the different parameterization used for launching a new instance of the context application. See *Launching new application instances* on page 27.
Application/<app_id> /**Schedules**		x				node	1	P	Contains the existing schedules for the context application. See *Scheduling applications* on page 32.

3.5.2 Application properties

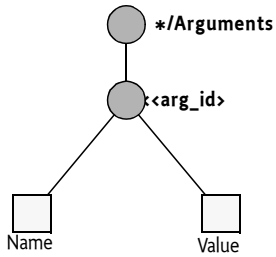
Standard application properties (name, icon, vendor etc) are represented as leaf nodes right under the $/Application/<app_id> node. The $/Application/<app_id>/ContainerID node contains a container provided identifier. The $/Application/<app_id>/PackageID node contains an identifier of the package that contains the code of this application. These two identifiers together provide enough information for the management server to correlate this application descriptor to one of the deployment packages installed on the device.

Further application model or container implementation specific attributes can be placed under the $/Application/<app_id>/Ext node.

3.5.3 Application Arguments

Both for launching and scheduling a new application, a management server needs to specify startup arguments. These arguments are repeated a number of times in the different trees. These arguments can be specified in the following structure:

Figure 3.6 *Argument sub-tree*



The Value node in the above structure is optional, but the only cases in which it can be missing are:

- It is used in a schedule, and
- This schedule was created by a local manager using the schedule method, of the ApplicationDescriptor class, and
- The corresponding startup argument type cannot be mapped to any of the allowed OMA DM types.

In this case this node must not be present, to indicate the lack of a viable mapping. Only the following OMA types must be used:

- bin – Passed to the application as byte[].
- chr - Correspond to java.lang.String type.
- int - Passed to the application as java.lang.Integer.
- float - Passed to the application as java.lang.Float.
- bool - Mapped to java.lang.Boolean.
- null - Passed as null references to the application.

This mapping is used in the opposite direction as well. The following table defines the different nodes in more detail.

Table 3.6 *Argument sub-tree*

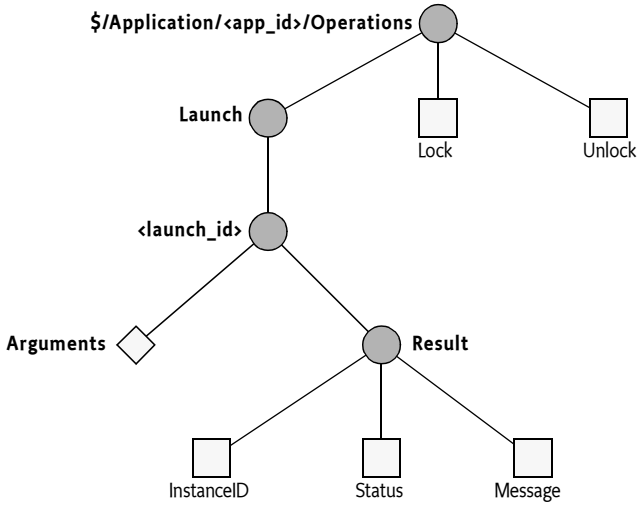
URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
***/Arguments**		x				node	1	A	This sub-tree contains the startup parameters that should be passed to the application instance at launch.
*/Arguments/**<arg_id>**	x	x		x		node	0..*	D	This sub-tree represents a startup argument. The name of this node can be any valid node name, for example, a number.

Table 3.6 *Argument sub-tree*

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
*/Arguments/<arg_id>/ **Name**		x	x			chr	1	A	The name of the startup argument. If the default value of this node is empty, which is not a valid startup argument name, then it must be replaced with a valid value.
*/Arguments/<arg_id>/ **Value**		x	x			bin chr int float bool null	0,1	A	This node contains the value of the startup argument. The default type of this node is null, which is a valid type. Both the type and the value can be replaced.

3.5.4 Launching new application instances

Figure 3.7 *Operations sub-tree*



The $/Application/<app_id>/Operations/Launch/<launch_id> sub-tree contains a particular parameterization of the context application. These sub-trees can be considered *canned* operations that can be used to launch an application with a given set of arguments. Management servers can launch the application by reusing an existing <launch_id> or creating a new one. These <launch_id> nodes are preserved until a management server explicitly removes them; they can be reused any number of times. The <launch_id> node of a new sub-tree is assigned by the management server when it is created. The management server should fill in the startup arguments in the Arguments sub-tree and then call the execute method to the $/Application/

<app_id>/Operations/Launch/<launch_id> node. These parameters must be stored persistently. The manager should set the ACLs for this node and must remove these parameters when they are not longer needed. This command must execute synchronously.

The application managed object must obtain the corresponding Application Descriptor service and call the launch method, passing it the specified arguments in a java.util.Map object. When the method returns, the Result subtree must be updated. If the launching was successful (i.e. no exception thrown), the Result/InstanceID node must then be updated with the instance identifier of the newly created application instance (ApplicationHandle.getInstanceId()), the Result/Status must be set to OK, and the Result/Message must be set to the empty string. Applications should ensure that their startup arguments can be mapped to this tree.

If the launch failed, the InstanceID node must be set to the empty string, the Status node set to the fully qualified class name of the thrown Java Exception, and the Message node set to the text returned by the getMessage method of the Exception. In both cases the set values are preserved until the next command is executed on the same <launch_id>, or that node is deleted.

The following table describes the nodes in detail:

Table 3.7 Application Descriptor Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Application/<app_id>/**Operations**		x				node	1	P	Groups operations
Application/<app_id> /Operations/**Lock**		x			x	null	1	P	Locks the context application when executed
Application/<app_id> /Operations/**Unlock**		x			x	null	1	P	Unlocks the context application when executed
Application/<app_id> /Operations/**Launch**		x				node	1	P	All launching parameters sub-tree
Application/<app_id> /Operations/Launch/**<launch_id>**	x	x		x	x	node	0..*	D	A specific set of launching parameters
Application/<app_id> /Operations/Launch/<launch_id>/**Arguments**		x				node	1	A	Sub-tree with arguments that must be passed to the application instance at launch. This sub-tree is further described at *Application Arguments* on page 26.
Application/<app_id> /Operations/Launch/<launch_id>/**Result**		x				node	1	A	This sub-tree contains the result of the latest execution of context <launch_id>.

Table 3.7 Application Descriptor Nodes

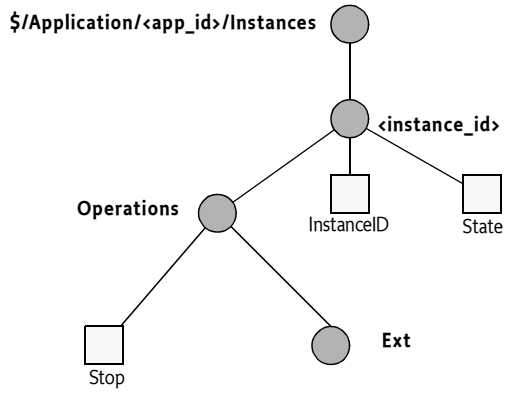
URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Application/<app_id> / Operations/Launch/ <launch_id>/Result/ **InstanceID**		x				chr	1	A	The ID of the created application instance. This value can be used to find the corresponding sub-tree under the $/Application/<app_id>/Instances node. The value of this node is empty if the last execution of this <launch_id> failed.
Application/<app_id> / Operations/Launch/ <launch_id>/Result/**Status**		x				chr	1	A	This node contains the status of the last EXEC command on this <launch_id>. It contains the value OK if the command was successful, otherwise it contains the fully qualified class name of the Java Exception that was thrown by the launch method of the corresponding application descriptor.
Application/<app_id> / Operations/Launch/ <launch_id>/Result/ **Message**		x				chr	1	A	Additional details of the last EXEC command on this <launch_id>. It must be empty if the command was executed successfully, otherwise, it must contain the text returned by the getMessage() method of the Java Exception that was thrown by the launch method of the corresponding application descriptor.

3.5.5 Locking and Unlocking

An EXEC command on the $/Application/<app_id>/Operations/Lock node can be used to lock the corresponding application. This command is synchronously executed by calling the lock method of the corresponding application descriptor. Unlocking the same application requires an EXEC command on $/Application/<app_id> /Operations/Unlock node, which is also executed synchronously.

3.5.6 Application Instances

Figure 3.8 *Application Instances Tree*



The currently running instances of an application are listed under the $/Application/<app_id> /Instances sub-tree. Each <instance_id> under this node corresponds to an Application Handle service. The current state of the application instance can be obtained from the State leaf node. All application instances must support the stop operation. This operation can be invoked by an EXEC command on the Stop node. This operation is executed synchronously by calling the destroy method of the corresponding Application Handle service.

Application model or container implementation specific operations can be placed in the Ext sub-tree.

Table 3.8 *Application Descriptor Nodes; Instances sub-tree*

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Application/<app_id>/ **Instances**		x				node	1	P	The sub-tree identified by this node contains the currently existing instances of this application.
Application/<app_id>/ Instances/**<instance_id>**		x				node	0..*	P	This sub-tree represents an instance of this application. The name of this node is the service.pid service property of the corresponding Application Handle service. This node name must be mangled to the device constraints.
Application/<app_id>/ Instances/<instance_id>/ **State**		x				chr	1	P	This node contains the state of the corresponding application instance. The value matches the application.state service property of the Application Handle service.
Application/<app_id>/ Instances/<instance_id>/ **InstanceID**		x				chr	1	P	The unmangled version of the service.pid property of the corresponding application handle.

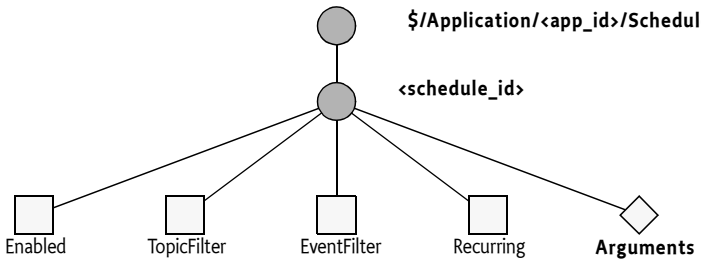
Table 3.8 Application Descriptor Nodes; Instances sub-tree

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Application/<app_id>/ Instances/<instance_id>/ **Operations**		x				node	1	P	This sub-tree contains the operations to manipulate the life cycle of this application instance.
Application/<app_id>/ Instances/<instance_id>/ Operations/**Stop**		x			x	null	1	P	An EXEC command on this node can be used to stop this application instance.
Application/<app_id>/ Instances/<instance_id>/ Operations/**Ext**		x				node	0,1	P	Application model-specific lifecycle operations (such as pause of MIDlets) should be placed under this node.

3.5.7 Scheduling applications

Scheduling applications is described in the $/Application/<app_id>/Schedules sub-tree. This sub-tree can contain enabled and disabled schedulings. The enabled schedules and the Scheduled Application services registered in the service registry are mapped one-to-one.

Figure 3.9 *Schedules sub-tree*



When a management server creates a new schedule, the server must assign the schedule a <schedule_id>. The created schedule will be disabled by default. The management server must update the attributes (TopicFilter, EventFilter, Recurring, and Arguments) of the schedule and enable the schedule afterwards. Management servers must not change the attributes of an enabled schedule. If the attributes need to be updated, the schedule must be disabled first. Only when the schedule is enabled may the application managed object call the schedule method of the corresponding ApplicationDescriptor service, and thereby create the Scheduled Application service. If setting the Enabled node to true fails, the schedule must not be initiated. When an enabled schedule is disabled, the corresponding Scheduled Application service must be unregistered.

In the <schedule_id>/Arguments sub-tree, startup arguments can be specified for the schedule. These arguments will be passed to the newly created application instance when the schedule is triggered.

When creating the schedule by a management server, only the OMA DM types listed in *Application Arguments* on page 26 can be used. Schedulings can also be created, however, using the Application Management Framework API (ApplicationDescriptor.schedule). Using this API, any serializable Java object is usable as a startup argument. If an object that cannot be mapped to one of the allowed OMA DM types is used as the value of an argument, the Value leaf-node will not be included in the DMT representation of that argument. Vice versa, if an application requires a startup argument that is not possible to represent in the OMA DM tree then this application cannot be correctly scheduled.

Created schedules must survive system restarts. The management server is responsible for cleaning up any created schedules. ApplicationDescriptor nodes in DMT are preserved if there exists any scheduling for that application (regardless of whether those were created by remote servers or local applications). Different implementations can use some garbage collection

mechanism to clean up these orphaned schedulings if needed. For invalid application descriptors in DMT, only the Valid node (value = false) , ApplicationId node and Schedules subtree is accessible, and they must be removed if the last remaining scheduling is deleted.

Table 3.9 Application Descriptor Nodes; Application Instances

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Application/<app_id> / **Schedules**		x				node	1	P	Groups the existing schedules for this application.
Application/<app_id> / Schedules/**<schedule_id>**	x	x		x		node	0..*	D	A specific schedule for this application. For server-created schedules, the name of this node is specified by the server. For scheduling created using the ApplicationDescriptor.schedule method, the id is given as parameter.
Application/<app_id> / Schedules/<schedule_id>/ **Arguments**		x				node	1	A	The startup arguments for this scheduling. These arguments will be passed to the application instance when the scheduling is triggered and a new instance is launched. The structure of this sub-tree is defined in *Application Arguments* on page 26.
Application/<app_id> / Schedules/<schedule_id>/ **Enabled**		x	x			bool	1	A	This node indicates whether this schedule is enabled. Only enabled schedules have the corresponding Scheduled Application service. The default value is false.
Application/<app_id> / Schedules/<schedule_id>/ **TopicFilter**		x	x			chr	1	A	This node contains the name of topic that should be listened to in this schedule. The value may end with a wildcard ("*", \u002A) , which indicates that all topics names with the specified prefix must be listened to. The default value of this node is an empty string. An empty string is invalid, it must be replaced with a valid value before enabling this schedule.
Application/<app_id> / Schedules/<schedule_id>/ **EventFilter**		x	x			chr	1	A	Filter of events to be listened to. The value is an OSGi-style filter of event attributes. The default value of this node is empty indicating matching all properties. An empty string must be converted to a null object in the associated method call .
Application/<app_id> / Schedules/<schedule_id>/ **Recurring**		x	x			bool	1	A	Specifies whether this schedule should be recurring. The default value of this node is false.

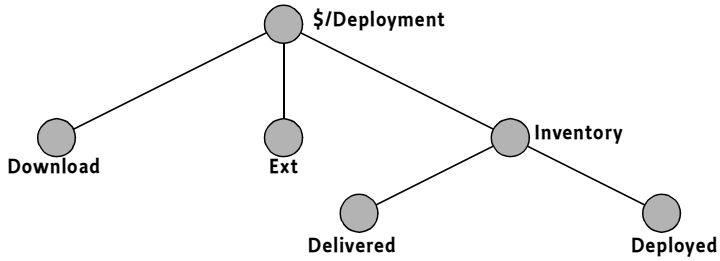
3.6 Deployment Management Object

The Deployment Management Object is a managed object that allows the downloading of arbitrary JAR files. These JAR files can contain Deployment Packages as defined by the *Deployment Admin Specification* on page 205 as well as *bundles*. These bundles can be either OSGi bundles or other applications that are stored in an Java Archive (JAR) file, for example Midlets and Xlets. This specification is not concerned with the differences between these Deployment Artifacts and therefore calls them *Deployment Artifacts* or artifacts for short.

Conceptually, the management system creates a *download instruction* in the $/Deployment/Download sub-tree. This instruction can be executed to download the Deployment Artifact to the device and then activate it. It is also possible for the device to have the content of Deployment Artifacts in a local storage area, which is represented by the $/Deployment/Inventory/Delivered sub-tree. This specification does not define how this data is delivered to this sub-tree, that is, there is no DMT operation to download the content of a deployment artifact in the delivered area, nor is there a standardized API. The content can be delivered through local means like Bluetooth, Wifi, CD, etc. The management system can only instruct the device to activate those delivered components.

The Deployment Management Object starts at the $/Deployment node. Figure 3.10 shows only the top level nodes, due to the large size of the Deployment Management Object. Later sections explain the descendants in more detail.

Figure 3.10 Mobile Tree for Deployment Management Object, Top Level Nodes



The nodes are described in more detail in Table 3.9.

3.6.1 Areas

The Deployment sub-tree has three different functional *areas*. These areas are:

- *Download* – The Download area is used to create a sub-tree containing the parameters of a download instruction. This instruction can be executed by executing the DownloadAndInstallAndActivate node in this sub-tree. If the DownloadAndInstallAndActivate operation is successful, the components are placed in the Inventory/Deployed sub-tree. The Download area is an execution tree only, and nodes can therefore be purged by the management system once they have been successfully executed.

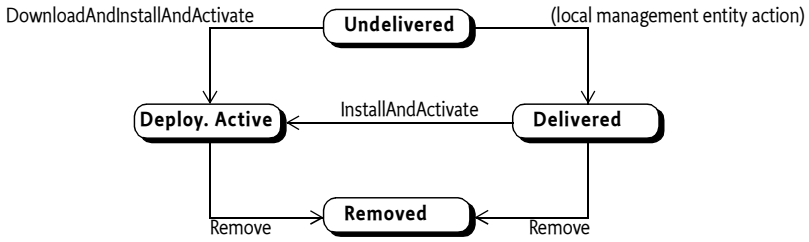
Table 3.10 Deployment Management Object Top-Level Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Deployment		x				node	1	P	Root node for all deployment related nodes.
Deployment/**Download**		x				node	1	P	This is the parent node for the download instruction. To download a deployment artifact, a sub-tree must be created below this node that provides the parameters for a DownloadAndInstallAndActivate operation.
Deployment/**Inventory**		x				node	1	P	The parent node of the Deployed and Delivered branches. Either branch represents an artifact that is either available on the device or installed and activated.
Deployment/Inventory/**Delivered**		x				node	1	P	The parent node of the placeholder branches containing the parameters of the delivered Deployment Artifacts.
Deployment/nventory/**Deployed**		x				node	1	P	The parent node of the placeholder branches containing the parameters of the deployed Deployment Artifacts.
Deployment/**Ext**		x				node	0,1	-	Extension node

- *Inventory/Delivered* – In some cases the delivery and installation of an artifact can take significant time. For example, the installation of a digital rights managed artifact can be delayed until the corresponding licenses are obtained by the user. The Delivered area consists of a sub-tree that represents artifacts that are resident but not yet deployed. This area acts as a kind of file storage. No specific DMT command or construct exists to download an artifact in this area, but implementations can use proprietary mechanisms to fill this area from CD, Bluetooth or other means. This sub-tree has a node Operations/InstallAndActivate. Executing this node will install the artifact and make it appear in the Deployed sub-tree. The Operations/Remove node can be executed to free up the storage.
- *Inventory/Deployed* – The Deployed area is where the installed deployment artifacts are represented. The Operations/Remove node can be executed to deactivate and uninstall a deployment artifact.

The states and their transitions are shown in Figure 3.11.

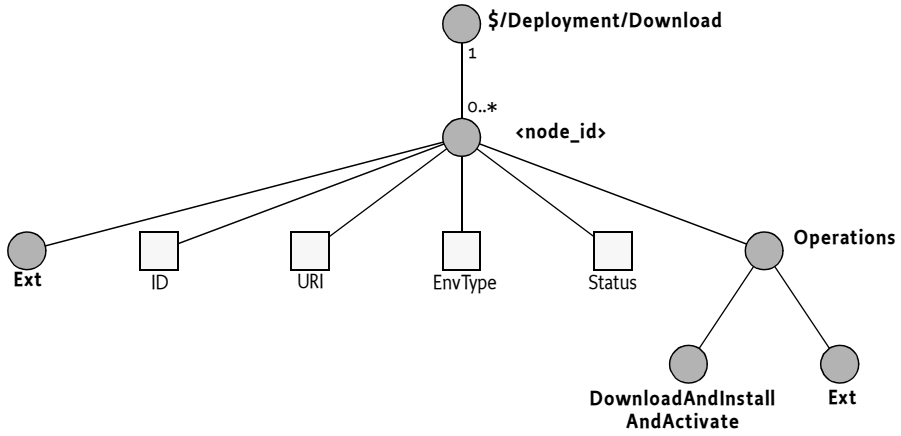
Figure 3.11 State diagram of Deployment Artifacts



3.6.2 Download sub-tree

The purpose of the Download sub-tree is to download a deployment artifact to the device. The initiator must create a new sub-tree under the $/Deployment/Download node. This node contains further nodes that describe the parameters of a download instruction. This sub-tree is depicted in Figure 3.12.

Figure 3.12 Deployment Management Object Download sub-tree



The nodes are explained in more detail in the following table:

Table 3.11 Deployment Management Object, Download sub-tree

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Deployment/Download/ **<node_id>**	x	x		x		node	0..*	D	This dynamically created node is the parent node of download instruction. Any node name can be used as long as it is unique under the Download node.
Deployment/Download/ <node_id>/**URI**		x	x			chr	1	A	This leaf node contains the URI of the deployment artifact to be downloaded. The URI points to a DLOTA Download Descriptor of the deployment artifact. See *DLOTA Download Descriptor* on page 50. The default is the empty string.
Deployment/Download/ <node_id>/**ID**		x	x			chr	1	A	This leaf node contains the globally unique ID of the Deployment Artifact. This value is set by the originator, the Management Server of the package. The default is the empty string.
Deployment/Download/ <node_id>/**Operations**		x				node	1	A	This is the parent node for download operations to be invoked on the deployment artifact identified by the ID node in this sub-tree.
Deployment/Download/ <node_id>/Operations/ **DownloadAndInstallAndActivate**		x			x	null	1	A	This node is used with *exec* command to initiate the download and immediate installation of a deployment artifact. The Deployment Package or standalone bundle is downloaded via the OMA DLOTA 1.0 protocol with the OSGi-specific Download Descriptor extension, see *DLOTA Download Descriptor* on page 50. When the command is executed, a node is created under the $/Deployment/Inventory/Deployed node with the appropriate parameters (including the same ID) of the installed DP. If the sub-tree for the deployment artifact already exists, that is, the operation is update then the ID is the same as the deployment artifact to be downloaded. The sub-tree parameters are then updated with the new information.
Deployment/Download/ <node_id>/Operations/**Ext**		x				node	0,1	-	Designates a branch of the Operations sub-tree into which vendor-specific extensions can be added.

Table 3.11 Deployment Management Object, Download sub-tree

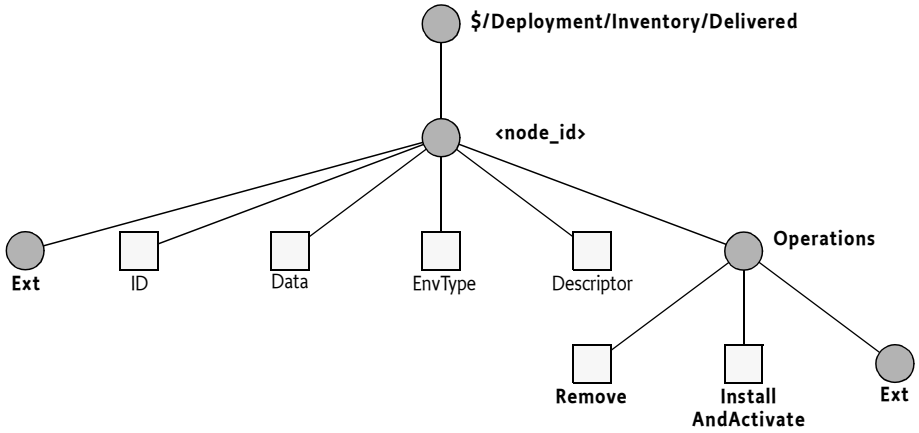
URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Deployment/Download/<node_id>/**Status**		x				int	0,1	A	The execution status of the device after an attempt to execute the download and/or deployment instruction. This value indicates the execution status following the invocation of the exec command. • 10 – Idle • *20* – Download Failed • *30* – Download Progressing. • *40* – Download Complete • *50* – Download and Deployment Progressing • *60* – Deployment Progressing • *70* – Deployment Failed • *80* – Deployment Successful See *DownloadAndInstallAndActivate Command* on page 46 for additional information about the Status node's transitions.
Deployment/Download/<node_id>/**EnvType**		x	x			chr	1	A	The environment for the deployment artifact to be downloaded. This value is: OSGi.<version>. For this specification the value of <version> is R4., therefore the node value is OSGi.R4.
Deployment/Download/<node_id>/**Ext**		x				node	0,1	-	A branch of the Download parameters sub-tree into which vendor-specific extensions can be added.

3.6.3 Delivered

The Delivered area contains deployment artifacts that are available on the device for installation and activation. From this area, deployment artifacts can be installed and activated. No specific Dmt Admin servic command exists to download an artifact into the Delivered area, this command is left to the implementation.

The Delivered sub-tree is depicted in Figure 3.13.

Figure 3.13 Deployment Management Object Delivered sub-tree



The nodes are explained in more detail in the following table.

Table 3.12 Deployment Management Object, Delivered sub-tree

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Deployment/Inventory/**Delivered**		x				node	1	P	Placeholder node for all delivered components.
Deployment/Inventory/Delivered/**<node_id>**		x				node	0..*	A	A local unique ID created by the local manager or the Deployment Managed Object. The chosen name should not be reused after deletion for a reasonably long time.
Deployment/Inventory/Delivered/<node_id>/**ID**		x				chr	1	A	This leaf node contains the globally unique ID of the Deployment Artifact. This value is set by the originator of the package (either Device Management System or a Local Manager for deployment artifacts delivered to the device via technology different from OMA DM).
Deployment/Inventory/Delivered/<node_id>/**Data**		x				bin	1	A	The data node contains an implementation-dependent representation of the delivered artifact.

Table 3.12 Deployment Management Object, Delivered sub-tree

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Deployment/Inventory/Delivered/<node_id>/**Descriptor**		x				xml	0,1	A	This leaf node includes the contents of DLOTA Download Descriptor of the artifact. See *DLOTA Download Descriptor* on page 50.
Deployment/Inventory/Delivered/<node_id>**/Operations**		x				node	1	A	Grouping node for operations
Deployment/Inventory/Delivered/<node_id>/Operations/**Remove**		x			x	null	1	A	This node can be executed to remove (uninstall) the artifact defined by this sub-tree. The node is used for exec commands only.
Deployment/Inventory/Delivered/<node_id>/Operations/**InstallAndActivate**		x			x	null	1	A	This node is used with the exec command to start the installation of a deployment artifact, which is in Delivered state and identified by the ID node of the same sub-tree as this node. After the command is executed successfully, this sub-tree is deleted. If a sub-tree under the $/Deployment/Inventory/Deployed node with the same ID node does not exist, it must be created, otherwise, the existing sub-tree must be updated because it is an update operation.
Deployment/Inventory/Delivered/<node_id>/Operations/**Ext**		x				node	0,1	-	Designates a branch of the Operations sub-tree into which vendor-specific extensions can be added.
Deployment/Inventory/Delivered/<node_id>/**EnvType**		x				chr	1	A	The environment for the deployment artifact to be downloaded. Definition of the leaf node value is: OSGi.<version>. For this specification the value of <version> is R4, therefore the node value is OSGi.R4.
Deployment/Inventory/Delivered/<node_id>/**Ext**		x				node	0,1	-	This placeholder node is the parent node of the OSGi environment extension branch and may be the placeholder of any vendor-specific extension.

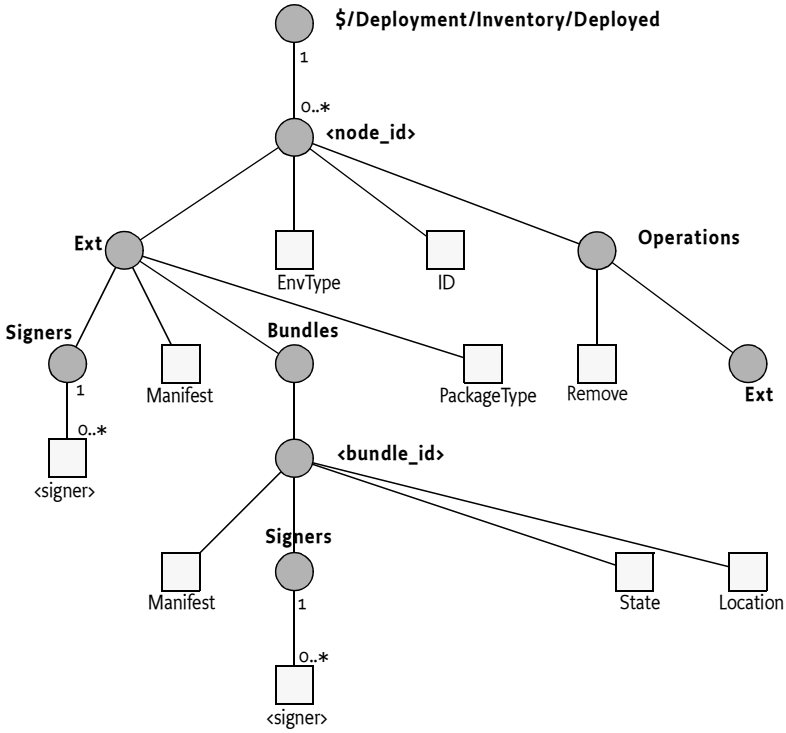
3.6.4 Deployed

The Deployed area reflects the deployment artifacts that are installed in the device (Bundles, Deployment Packages, and others). Deployment artifacts can be installed on the device through executing the DownloadAndInstallAndActivate node or the InstallAndActivate node, when the data of the deployment artifact is already present on the device.

The Deployed area also reflects deployment artifacts deployed directly via the Deployment Admin service or Framework API. That is, deployed independently from the commands of the management system.

Deployment Artifacts are stored in the tree under a node with a unique name <node_id> that is automatically generated by Deployment Management Object when a artifact becomes available in this sub-tree. The sub-tree is depicted in Figure 3.14.

Figure 3.14 Deployment Management Object Deployed sub-tree



The nodes are further explained in the following table.

Table 3.13 Deployment Management Object Top Level Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Deployment/Inventory/**Deployed**		x				node	1	P	Placeholder node for all deployed deployment artifacts.
Deployment/Inventory/Deployed/**<node_id>**		x				node	0..*	A	Sub-tree for a deployed artifact. The <node_id> must be generated by the Deployment Managed Object. The chosen name should not be reused after deletion for a reasonably long time.

Table 3.13 Deployment Management Object Top Level Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Deployment/Inventory/ Deployed/<node_id>/**ID**		x				chr	1	A	This leaf node contains the globally unique ID of the Deployment Artifact. This value is set by the originator of the package (either Device Management System or a Local Manager for deployment artifacts delivered to the device via technology different from OMA DM).
Deployment/Inventory/ Deployed/<node_id>/ **EnvType**		x				chr	1	A	This leaf node holds the value that indicates the environment for the Deployment Artifact to be downloaded. Definition of the leaf node value is OSGi.<version>. For this specification the value of <version> is R4, therefore the node value is OSGi.R4.
Deployment/Inventory/ Deployed/<node_id>/ **Operations**		x				node	1	A	Operations grouping node
Deployment/Inventory/ Deployed/<node_id>/ Operations/**Remove**		x			x	null	1	A	Executing this node will remove this Deployment Artifact.
Deployment/Inventory/ Deployed/<node_id>/ Operations/**Ext**		x				node	0,1	-	Designates a branch of the Operations sub-tree into which vendor-specific extensions can be added.
Deployment/Inventory/ Deployed/<node_id>/**Ext**		x				node	1	A	Placeholder for OSGi-specific extensions
Deployment/Inventory/ Deployed/<node_id>/Ext/ **Manifest**		x				chr	0,1	A	The content of the Deployment Package's manifest.
Deployment/Inventory/ Deployed/<node_id>/Ext/ **Signers**		x				node	0,1	A	This node is the parent of nodes that specify the signers of the Deployment Package.
Deployment/Inventory/ Deployed/<node_id>/Ext/ Signers/**<signer>**		x				chr	1..*	A	A signer of the Deployment Package. The node value is the semicolon-separated list of the Subjects (distinguished Name) of the X.509 Certificate chain. The last item is the root.

Deployment/Inventory/ Deployed/<node_id>/Ext/ **PackageType**		x				int	1	A	This node allows querying of the package type. Possible values are:
									`OSGi.DP = 1`
									`OSGi.bundle = 2`

Deployment/Inventory/ Deployed/<node_id>/Ext/ **Bundles**		x				node	0,1	A	Sub-tree of bundles that are contained in the Deployment Package or a standalone bundle.

Table 3.13 Deployment Management Object Top Level Nodes

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Deployment/Inventory/Deployed/<node_id>/Ext/Bundles/**<bundle_id>**		x				node	1..*	A	Start of a sub-tree that represents a contained bundle. The <bundle_id> node name must be equal to the bundle id.
Deployment/Inventory/Deployed/<node_id>/Ext/Bundles/<bundle_id>/**Location**		x				chr	1	A	This leaf node contains the location of the bundle.
Deployment/Inventory/Deployed/<node_id>/Ext/Bundles/<bundle_id>/**Manifest**		x				chr	1	A	The content of the bundle's manifest.
Deployment/Inventory/Deployed/<node_id>/Ext/Bundles/<bundle_id>/**State**		x				int	1	A	The state of the bundle as returned from the Bundle method getState(). This state is one of the following: • 0 – Not Available • 2 – Installed • 4 – Resolved • 8 – Starting • 16 – Stopping • 32 – Active
Deployment/Inventory/Deployed/<node_id>/Ext/Bundles/<bundle_id>/**Signers**		x				node	0,1	A	This node is the parent of nodes that specify the signers of the bundle.
Deployment/Inventory/Deployed/<node_id>/Ext/Bundles/<bundle_id>/Signers/**<signer>**		x				chr	1..*	A	A signer of the bundle. The node value is the semicolon-separated list of the Subjects (distinguished Name) of the X.509 Certificate chain. The last item is the root.

3.6.5 Example sub-tree

The following example shows a sub-tree with a single bundle:

```
$/Deployment/Inventory/Deployed
   2                              // <node_id>
      ID                          = "com.acme.rp.db"
      EnvType                     = "OSGi.R4"
      Operations
         Remove
      Ext
         PackageType              = 2
         Bundles
            6                     // <bundle_id>
               State              = 4
               Manifest           = "Manifest-Version: 1.0
```

```
                                    Bundle-Activator: ..."
            Location          = "com.acme.rp.db"
            Signers
              1               "cn=Sign, ou=ACME, ..."
```

The next example shows a sub-tree with a Deployment Package:

```
$/Deployment/Inventory/Deployed
   xyztas2731                 // <node_id>
      ID                      = com.acme.dp.512
      EnvType                 = OSGi.R4
      Operations
         Remove
      Ext
         PackageType          = 1
              Manifest        = "Manifest-Version: 1.0
                                 Deployment-Package-
                                 SymbolicName: ..."
         Signers
            1                 = "cn=Signe, ou=ACME, ..."
         Bundles
            3                 // <bundle_id>
               State          = 32
               Manifest       = "Manifest-Version: 1.0
                                 Bundle-Activator: ..."
               Location       = "com.acme.customize"
```

3.6.6 Command Execution

The Deployment Management Object uses dedicated nodes that represent a specific command. These nodes are resident in all three areas. They are parented by an Operations node that groups the different possible command nodes. Execution of a command node must use the parent sub-tree as its context. This tree is called the *context tree*.

Exec commands are acknowledged synchronously. Successful return from the execute method indicates only that the execution is initiated. One exec command may require more than one local operation, for example DownaloadAndInstallAndActivate. After all the operations are finished, the Deployment Managed Object must send back the outcome of the execution to the initiator using an asynchronous Generic Alert.

3.6.6.1 Remove Command

A Remove node exists in the sub-trees $/Deployment/Inventory/Delivered as well as in the $/Deployment/Inventory/Deployed sub-tree. Performing an execute operation on the Remove node must remove the deployment artifact that is described by the context tree.

The actual removal of the Deployment Artifact is performed asynchronously with the execute method. The successful return from the execute method indicates that removal of the deployment artifact can begin.

After the deployment artifact is removed, the Deployment Management Object must send the outcome with a Generic Alert and remove the context tree.

The Remove command for the Delivered context tree requires the following Alert parameters:

- *code* – 1226
- *correlator ID* – Any value passed from the management server's execute command.
- *source* – $/Deployment/Inventory/Delivered/<node_id>.
- *type* – org.osgi.deployment.delivered.remove
- *mark* – fatal | critical | minor | warning | informational | harmless | indeterminate or not set.
- *data* – An integer with the *Result Code* on page 48

The Remove command for the Deployed context tree, which corresponds to the uninstallForced method in Deployment Admin service, requires the following Alert parameters:

- *code* – 1226
- *correlator ID* – Any value passed from the management server's execute command.
- *source* – $/Deployment/Inventory/Deployed/<node_id>.
- *type* – org.osgi.deployment.deployed.remove
- *mark* – fatal | critical | minor | warning | informational | harmless | indeterminate or not set.
- *data* – An integer with the *Result Code* on page 48

3.6.6.2 InstallAndActivate Command

The InstallAndActivate node resides in the sub-tree for a deployment artifact that is stored in the Delivered area. This node takes the data that is referenced in this context tree and installs the artifact. If an artifact with the same ID is already installed, the existing deployment artifact must be updated.

If the execute method on the InstallAndActivate node is successful, the install can begin. The actual installation is performed asynchronously with the execute method. If an error is detected during the install method, this error must be reported and the deployment artifact must not be installed.

After the installation is finished, successfully or not, the Deployment Management Object must send a Generic Alert to the initiator. If the installation was successful, the Deployment Management Object must remove the context tree and free up the data associated with the delivered artifact.

The InstallAndActivate command for the Deployed context tree requires the following Alert parameters:

- *code* – 1226
- *correlator ID* – Any value passed from the management server's execute command.
- *source* – $/Deployment/Inventory/Deployed/<node_id>.
- *type* – org.osgi.deployment.installandactivate
- *mark* – fatal | critical | minor | warning | informational | harmless | indeterminate or not set.
- *data* – And integer with the *Result Code* on page 48

The newly installed or updated Deployment Artifact must appear in the Deployed area.

3.6.6.3 DownloadAndInstallAndActivate Command

When an exec command is sent to the DownloadAndInstallAndActivate node, the Deployment Management Object sends a status command back to the server. If the exec command is successful, the Deployment Management Object starts the download and immediate deployment of the downloaded package. After the operations are finished, the Deployment Management Object must send a response back to the initiator using a single Generic Alert. The source URI of the alert must be the of the dynamic node describing the deployed deployment artifact, that is, $/Deployment/Inventory/Deployed/<node_id>.

The deployment artifact identified by the URI in the context tree is downloaded via [3] *Generic Content Download Over The Air, OMA DLOTA 1.0* with the OSGi specific extension defined in *DLOTA Download Descriptor* on page 50. It is the responsibility of the Deployment Management Object to download only OSGi deployment artifacts. The deployment artifact must be immediately activated via the applicable deployment API.

Pre-Condition:

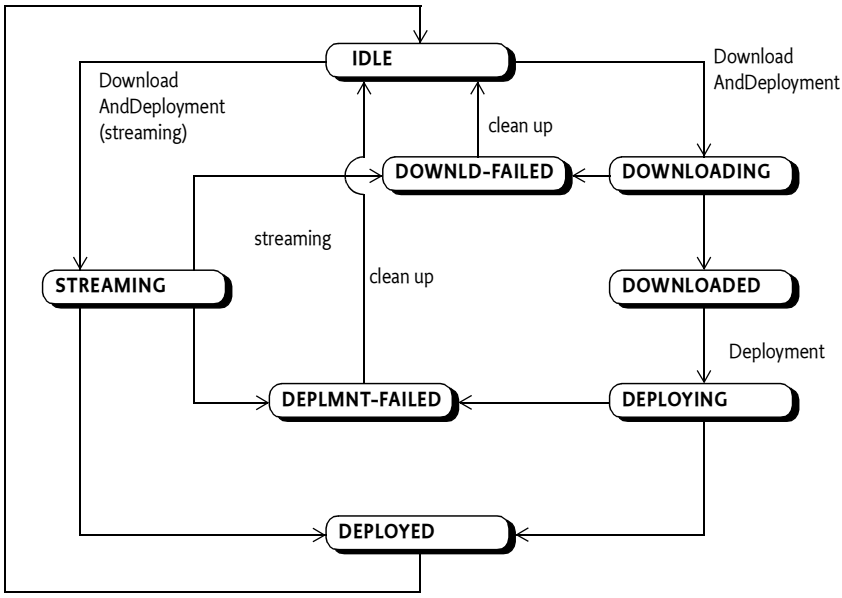
- $/Deployment/Download/<node_id> dynamic node creation
- The following objects need to be set with an appropriate value:

```
$/Deployment/Download/<node_id>/URI
$/Deployment/Download/<node_id>/ID
$/Deployment/Download/<node_id>/EnvType.
```

After the successful command execution, a sub-tree under the $/Deployment/Inventory/Deployed node is created for the deployment artifact, including the ID node in the download branch. If such a sub-tree already exists, the parameters of the deployment artifact must be updated.

During the downloading, the managed object can optionally report progress in the Status node. The possible state values are depicted in Figure 3.15.

Figure 3.15 Execution States



The states have the following values and semantics:

- *IDLE* – (10) No data is available
- *DOWNLOAD-FAILED* – (20) Download failed and no data was received.
- *DOWNLOADING* – (30) A download has started and that 0 or more bytes of data have been downloaded.
- *DOWNLOADED* – (40) Data is available after download has been completed successfully.
- *STREAMING* – (50) Download and Deployment started in streaming fashion and are progressing.
- *DEPLOYING* – (60) The Deployment is currently running, but has not yet completed.
- *DEPLOYMENT-FAILED* – (70) Deployment failed.
- *DEPLOYED* – (80) Deployment complete

After the requested operation finishes, the DM server is notified about the outcome of the operation with a Generic Alert message. The status is then DEPLOYED, DOWNLOAD-FAILED, or DEPLOYMENT-FAILED. This state must remain until the Generic Alert is sent to the management server.

The DownloadAndInstallAndActivate command for the Download context tree requires the following Alert parameters:

- *code* – 1226
- *correlator ID* – Any value passed from the management server's execute command.
- *source* – $/Deployment/Inventory/Deployed/<node_id>. This is the newly created node, not the node in the Download tree.
- *type* – org.osgi.deployment.downloadandinstallandactivate
- *mark* – fatal | critical | minor | warning | informational | harmless | indeterminate or not set.
- *data* – An integer with the *Result Code* on page 48

If the server needs to retrieve additional information, such as Status, the server can query the device for those specific nodes.

3.6.6.4 Result Code

The result code of the operation must be sent as an integer value in the Data element of the alert message. The Result Code must be one of the values defined below:

- 200 – Successful. The requested command is executed successfully.
- 250 – Successful but with Bundle start warning. One or more bundles
- couldn't be started. The operation was not rolled back. The Management
- Server is expected to resolve the missing dependencies or other errors
- with an appropriate action.
- 251 - Successful but with removal warning. Not all parts of the deployment artifact could be removed.
- 401 – User Cancelled. Either the download or the deployment of the deployment artifact was cancelled by the user.
- 402 – Corrupted Deployment Package. Physical damage of the package, did not store correctly. Detected, for example, by mismatched CRC.
- 403 – Package Mismatch. Based on the current device characteristics, the deployment artifact is wrong. That is, the package is targeted to another environment than the OSGi environment. For example, the value of the EnvType node of the Download/<node_id> subtree is different than OSGi.R4.
- 404 – Not Acceptable Content. The content is not an OSGi deployment artifact, for example, the Download Descriptor of the package indicates different value in the EnvType attribute of the environment element than defined in OSGi DLOTA extension or the package to be downloaded is not a JAR.
- 405 – Authentication Failure. An Authentication Failure was encountered during the download initiation, for example, the Download Server authentication failed.
- 406 – Request Timed Out. The device could not fulfill a server request because a timeout was encountered, for example, a from hung server request.
- 407 – Undefined Error. Indicates failure not defined by any other error code.
- 408 – Malformed or Bad URL. The URL provided for DLOTA download did not provide access to the package, for example, server down, incorrect URL, and service errors.
- 409 – The Download Server is temporarily unavailable.
- 410 – Download Descriptor error. The device could not interpret the DLOTA Download Descriptor. Typically this error results from a syntactic error, or the package does not match the attributes defined in the Download Descriptor. The Deployment Package was rejected.
- 411 – Authorization Failure. An Authorization Failure was encountered
- during the requested operation execution, for example a Java Permission is missing to fulfill the request.
- 450 – Deployment error: ordering. The manifest is not the first file in the stream, or bundles do not precede resource files.
- 451 – Deployment error: missing header.
- 452 – Deployment error: bad header. This error indicates a syntax error in any manifest header.

- 453 – Deployment error: missing fix0pack target. Fix pack version range does not match the version of the target deployment package, or the target deployment package of the fix pack does not exist.
- 454 – Deployment error: missing bundle. A bundle in the Deployment Package is marked as absent, but no such bundle is in the target deployment package.
- 455 – Deployment error: missing resource. A resource in the deployment package is marked as absent, but no such resource is in the target deployment package.
- 456 – Deployment error: failed signature authentication. The digital signature(s) of the deployment package could not be validated.
- 457 – Deployment error: bundle name error. Bundle symbolic name is not the same as is defined by the deployment package manifest.
- 458 – Deployment error: foreign customizer. Matched resource processor service is a customizer from another deployment package.
- 460 – Deployment error: bundle sharing violation. Bundle with the same symbolic name already exists.
- 461 – Deployment error: resource sharing violation. This error code results if a resource already exists.
- 462 – Deployment error: commit error. A resource processor is not able to commit the operations.
- 463 – Deployment error: undefined. An undefined error occurred during deployment. This error is also returned if security exceptions occur during package processing.
- 464 – Deployment error: resource processor missing. Resource processor required by the package is not found.
- 465 – Deployment error: deployment session creation time-out. Deployment Manager is busy with other requests and the blocked deployment operation was not started, because a timeout was encountered.
- 470 -499 – Device Error. Vendor-defined error was encountered for the operation with vendor-specified result code.
- 500 – Download Server Error.
- 501-549 – Reserved for Future Use.
- 550 -599 – Vendor Download Server Error. Vendor-specified download server error was encountered for operations with vendor-specified result code.

3.6.6.5 URI of the dynamic node

The URI of the dynamic node created, updated, or removed under $/Deployment/Inventory/Deployed or $/Deployment/Inventory/Delivered node must be sent as the *source* of the Generic Alert. This rule allows the Management Server to identify the result node. If the command execution is unsuccessful, this URI is the URI of the sub-tree for which the exec command was invoked, for example $/Deployment/Invenotry/Download/<node_id>.

3.6.6.6 Alert Types for the Deployment Management Object

One of the following alert types must be used in a Generic Alert message originating from a Deployment Management Object. The alert types are used to identify the operation that was performed on the device.

`org.osgi.deployment.downloadandinstallandactivate`

```
org.osgi.deployment.delivered.remove
org.osgi.deployment.deployed.remove
org.osgi.deployment.installandactivate
```

3.6.6.7 Correlator

If the server passes a correlator to the client in the exec command for an operation, the client must return the same value to the server in the correlator field of the Generic Alert message.

If the server does not pass a correlator to the client in the exec command for an operation, the client must not send a correlator to the server in the correlator field of the Generic Alert message.

3.6.7 Tree management

After an exec command to Remove, InstallAndActivate, or DownloadAndInstallAndActivate node, it is the device's responsibility to reflect the changes in the Inventory sub-tree. After the deployment artifact is delivered to and deployed on the device, it is tracked with the ID node.

Deletion of a sub-tree headed by <node_id> under the Download node needs to be conducted after successful or unsuccessful download and installation attempts. This specification, however, does not address when such deletions should occur. The management entity may choose to delete it as soon as the requested operation is successfully or unsuccessfully terminated, or whenever prompted to do so by the device management server.

If a Local Manager needs to receive the Generic Alert after the exec command execution, then it must register a Remote Alert Sender service for a given principal. The same principal must be used when opening the session. This is similar to remote management servers.

3.6.8 DLOTA Download Descriptor

The [3] *Generic Content Download Over The Air, OMA DLOTA 1.0* Download Descriptor is extensible. Extensions can be made to the Download Descriptor by defining the extension data in a separate name space. That way, extension names will not collide with the standard metadata.

The JAR content to be downloaded may be processed by special rules of the targeted environment. The environment element indicates the specific environment via its XML name space. This element has an optional XML attribute named envtype, which is used to select the appropriate background content handler to process it. The OSGi-specific value of this envtype attribute is defined below.

- *Definition* – Container for identification of the environment agent, which processes the JAR content. Extension introduced by OSGi.
- *Status* – Download Descriptor: Optional. User Agent: Optional
- *Datatype* – A complex type with an optional envtype XML attribute as URI.
- *Refinement* – Extension introduced by OSGi.

The envtype attribute value identifies the content handler of the JAR package.

3.6.8.1 The OSGi Specific Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema
   targetNamespace="http://www.osgi.org/xmlns/dd/v.1.0"
   xmlns: md="http://www.osgi.org/xmlns/dd/v.1.0"
   xmlns:xsd="http://www.w3.org/2001/XMLSchema"
   elementFormDefault="qualified">

   <xsd:element name="environment" >
      <xsd:complexType>
         <xsd:attribute name="envtype"
            type="xsd:anyURI" use="required"/>
      </xsd:complexType>
   </xsd:element>
</xsd:schema>
```

The name space qualified environment element indicates that the content is targeted to the OSGi platform.

The envtype attribute has the http://www.osgi.org/xmlns/dd/DP value indicating the OSGi Deployment Package format and http://www.osgi.org/xmlns/dd/bundle value indicating the OSGi standalone bundle. This value is used to select the content handler for OSGi packages for further processing. The DLOTA DD descriptor refers to the mime type of the JAR package (application/java-archive).

Example of a DLOTA 1.0 DD of an OSGi Deployment Package:

```
<?xml version="1.0" encoding="UTF-8"?>
<media
      xmlns="http://www.openmobilealliance.org/xmlns/dd"
      xmlns:dd="http://www.osgi.org/xmlns/dd/v.1.0" >
   <objectURI>
      http://acme.com/management/bundle.jar
   </objectURI>
   <size>1234</size>
   <type>application/java-archive</type>
   <dd:environment
         envtype="http://www.osgi.org/xmlns/dd/DP" />
</media>
```

3.7 Policy Management Object

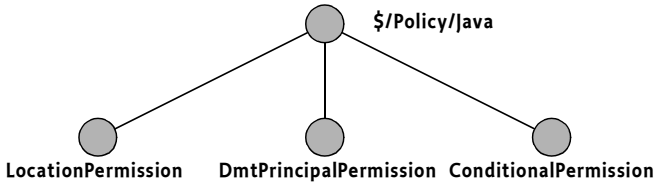
This section describes the part of the Mobile Management Tree that controls the permissions in the OSGi Service Platform. This sub-tree manages the following aspects:

- *Conditional Permission* – Contains the Conditional Permission Info objects that are part of the Conditional Permission Admin service. This part of the sub-tree is described at *Conditional Permission Management Object* on page 54.

- *Location Permission* – Contains the Permission Admin service Permission Info objects that are associated with a location of a bundle.*Location Permission Management Object* on page 53.
- *Principal Permission* – Maintains a set of permissions that are associated with a principal that is used in the Dmt Admin service. No related OSGi service can manage these principals. *Dmt Principal Permission Management Object* on page 54.

This tree is depicted in Figure 3.16.

Figure 3.16 *Policy Management Object sub-tree*



Updates to this tree must use an atomic session. A Policy sub-tree can be absent if the underlying service is missing.

Table 3.14 *Policy Management Object nodes*

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
Policy		x				node	1	P	Parent node for all policies
Policy/**Java**		x				node	1	P	Parent node for all Java based policies

3.7.1 Permission and Conditional Permission Info Encoding

The OSGi Permissions are described with an array of PermissionInfo and ConditionInfo objects. This type of information is encoded with a string when it must be represented in the Mobile Management Tree.

Both classes have a getEncoded method that returns a String object with the encoded form. An array is the repetition of the encoded form appended with a new line character ('\n' \u000A).

For example, an array with three permissions (where ↵ is a new line character):

```
(org.osgi.framework.PackagePermission "*" "IMPORT")↵
(org.osgi.framework.ServicePermission "*" "GET")↵
(org.osgi.framework.AdminPermission   "*" "resource")↵
```

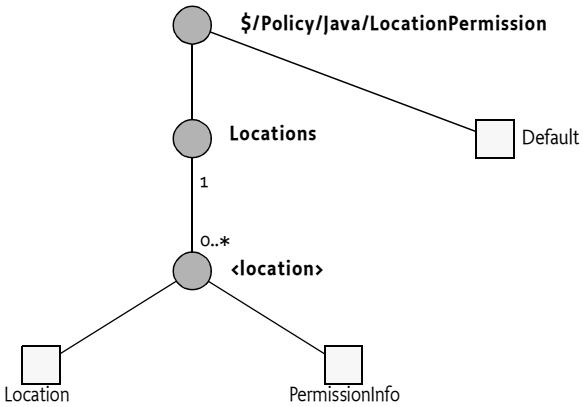
An example of an array with two Condition objects:

```
[org.osgi.service.condpermadmin.BundleLocationCondition
     "http://example.com/*"]↵
[org.osgi.util.gsm.IMSICondition "35817239027340"]↵
```

3.7.2 Location Permission Management Object

Figure 3.17 The node $/Policy/Java/LocationPermission contains data that represents the bundle's permissions as defined by the Permission Admin service. This service maintains an association between a location and an array of Permission Info objects. This object is modeled as a sub-tree as depicted in Figure 3.17.

Figure 3.18 *Bundle Sub-tree*



The following table describes the different nodes.

Table 3.15 *Policy Management Object nodes*

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
LocationPermission		x				node	1	P	Parent node for all Permission Admin maintained permissions.
LocationPermission/ **Default**	x	x	x	x		chr	0,1	D	The value of this node is a list of encoded PermissionInfo objects. These permissions are assigned when a Conditional Permission Admin service is absent and no permissions are associated with a bundle's location. The Default node is absent when getDefaultPermissions() method returns null in the Permission Admin Service. Deleting the Default node is equivalent to calling setDefaultPermissions method with null. Having null as default permissions is *not* the same as having a zero length array. The null case implies AllPermission, the empty array case implies a default of no permissions.

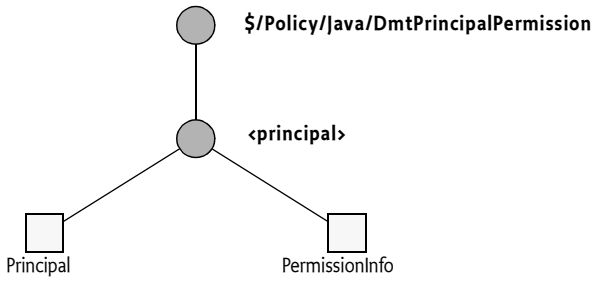
Table 3.15 *Policy Management Object nodes*

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
LocationPermission/ **Locations**		x				node	1	P	Parent node for available bundle permissions, identified by location.
LocationPermission/ Locations/**<location>**	x	x		x		node	0..*	D	The Permission Admin service grants permissions based on location of the bundle. This location must be in mangled form.
LocationPermission/ Locations/<location>/ **Location**		x	x			chr	1	A	Bundle location in unmangled form.
LocationPermission/ Locations/<location>/ **PermissionInfo**		x	x			chr	1	A	The encoded form of an array of Permission Info objects as described in *Permission and Conditional Permission Info Encoding* on page 52.

3.7.3 Dmt Principal Permission Management Object

The DmtPrincipalPermission sub-tree contains Java 2 permissions that are associated with a given principal. The principal is a string that identifies a management entity. It is given to the Dmt Admin service by the different protocol adapters at session creation. Based on this string, and on what is specified in this sub-tree, the DMT Admin will assign permissions to the different management servers. This procedure is discussed in *DMT Admin Service Specification* on page 303. No corresponding service API exists for managing this sub-tree. The structure of the sub-tree is given in Figure 3.19.

Figure 3.19 *Dmt Principal sub-tree*



The nodes are described in the following table.

3.7.4 Conditional Permission Management Object

The $/Policy/Java/ConditionalPermission tree represents the Conditional Permission Admin service. This service maintains the permissions in a ConditionalPermissionInfo object. This object is a tuple of encoded Condition objects and encoded Permission objects.

Table 3.16

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
DmtPrincipal Permission		x				node	1	P	Parent node
DmtPrincipalPermission/ **<principal>**	x	x		x		node	0..*	D	Name of the principal. One node exists per principal. The name of the node must be mangled.
DmtPrincipalPermission/ <principal>/**Principal**		x	x			chr	1	A	The full name of the principal in unmangled form.
DmtPrincipalPermission/ <principal>/ **PermissionInfo**		x	x			chr	1	A	The permissions associated with this principal. These permissions are encoded as described in *Permission and Conditional Permission Info Encoding* on page 52.

This tuple can be anonymous (the name is assigned by the Conditional Permission Info service) or can have a given name. The ConditionalPermissionInfo object is represented by a node that has a Name node, a node for the Conditions, and a node for the Permissions. These nodes are grouped under a group node. The name of the group node is irrelevant; if the Name node has a value, the tuple is stored under that name. If the Name node has no value, the Conditional Permission Admin service will generate a name. The structure of the tree is depicted in Figure 3.19. Table 3.17 on page 56 contains the details.

Figure 3.20 Conditional Permission sub-tree

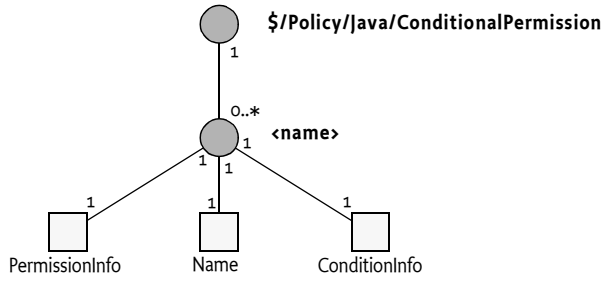


Table 3.17 Conditional Permission Admin Managed Object

URI	Add	Get	Replace	Delete	Exec	Type	Cardinality	Scope	Description
ConditionalPermission		x				node	0,1	P	Parent node of the Conditional Permission Info objects. If this node is absent, the Conditional Permission service is absent.
ConditionalPermission/ **<name>**	x	x		x		node	0..*	D	The name of the Conditional Info entry. This name must be mangled. If the condition name is an empty string, the name of the node must be 2jmj7l5rSwoyVb_vlWAYkK_YBwk.
ConditionalPermission/ <name>/**Name**		x	x			chr	1	A	Returns the real name as used by the Conditional Permission Info. If this node is set when the session is closed, the given name is used. Otherwise, an anonymous tuple is created that has a name defined by the Conditional Permission Admin service.
ConditionalPermission/ <name>/**ConditionInfo**		x	x			chr	1	A	The conditions that are associated with this Conditional Permission Info node. These conditions are encoded as described in *Permission and Conditional Permission Info Encoding* on page 52.
ConditionalPermission/ <name>/**PermissionInfo**		x	x			chr	1	A	The permissions associated with this condition. These permissions are encoded as described in *Permission and Conditional Permission Info Encoding* on page 52.

3.8 OMA DM Compatibility

The OSGi Mobile Management Tree is defined to be compatible with the OMA DM Management Specification 1.2 and later. The following table defines the managed object identifiers for the different Management Objects.

Table 3.18 Management Objects

OSGi MO Identifier	Management Object
org.osgi/1.0/DeploymentManagementObject	*Deployment Management Object* on page 34
org.osgi/1.0/LogManagementObject	*Log Management Object* on page 15
org.osgi/1.0/MonitorManagementObject	*Monitor Management Object* on page 19
org.osgi/1.0/ConfigurationManagementObject	*Configuration Management Object* on page 10
org.osgi/1.0/PolicyManagementObject	*Policy Management Object* on page 51
org.osgi/1.0/ApplicationManagementObject	*Application Model Management Object* on page 23
org.osgi/1.0/OSGiMobileManagementObject	*Mobile Management Tree* on page 9

3.9 References

[1] *OMA DM public document repository*
http://member.openmobilealliance.org/ftp/Public_documents/DM/2004

[2] *RFC 2396 Uniform Resource Identifiers (URI): Generic Syntax*
http://www.ietf.org/rfc/rfc2396.txt

[3] *Generic Content Download Over The Air, OMA DLOTA 1.0*
http://www.openmobilealliance.org/release_program/docs/Download/v1.0-20040625/OMA-Download-OTA-V1_0-20040625-A.pdf

[4] *OMA Device Management Protocol, Version 1.2.*
Open Mobile Alliance . OMA-TS-DM-Protocol-V1_2_0,
URL:http://www.openmobilealliance.org

[5] *Generic Content Download Over The Air Specification Version 1.0*
Open Mobile Alliance , OMA-Download-OTA-v1_0
http://www.openmobilealliance.org

[6] *OMA DM Draft Trap-MO 1.3*
http://member.openmobilealliance.org/ftp/public_documents/dm/2004/OMA-DM-2004-0120R03-Trap-MO.zip

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.

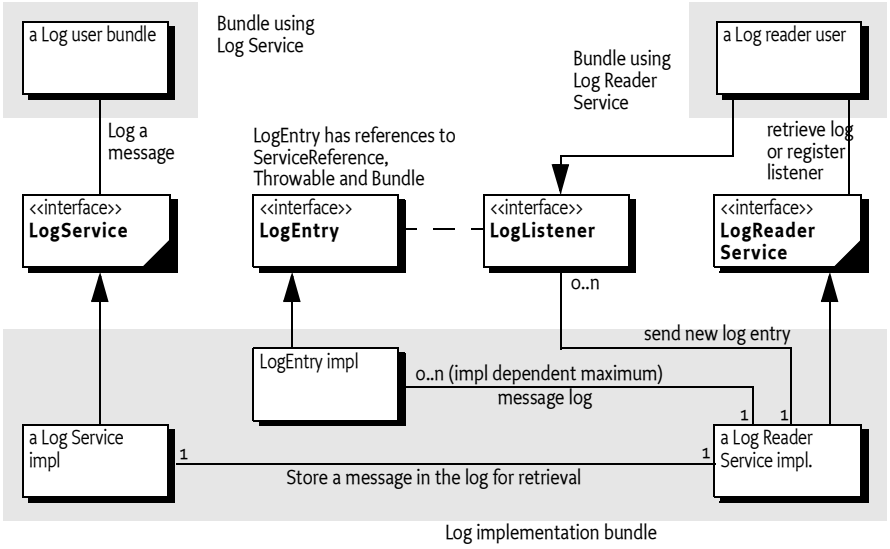
This specification defines the methods and semantics of interfaces which bundle developers can use to log entries and to retrieve log entries.

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 101.1 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 101.1 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 101.2, “Mapping of Bundle Events to Log Entries,” on page 63.

Table 101.2 Mapping of Bundle Events to Log Entries

Log Entry method	Information about Bundle Event
getLevel()	LOG_INFO
getBundle()	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 getBundle() on the BundleEvent object.
getException()	null
getServiceReference()	null
getMessage()	The message depends on the event type: • 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 101.3, “Mapping of Service Events to Log Entries,” on page 64.

101.6.3 Framework Events Mapping

A Framework Event is mapped to a LogEntry object according to Table 101.4, “Mapping of Framework Event to Log Entries,” on page 64.

Table 101.3 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: • REGISTERED – "ServiceEvent REGISTERED" • MODIFIED – "ServiceEvent MODIFIED" • UNREGISTERING – "ServiceEvent UNREGISTERING"

Table 101.4 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: • STARTED – "FrameworkEvent STARTED" • ERROR – "FrameworkEvent ERROR" • PACKAGES_REFRESHED – "FrameworkEvent PACKAGES REFRESHED" • STARTLEVEL_CHANGED – "FrameworkEvent STARTLEVEL CHANGED" • WARNING – "FrameworkEvent WARNING" • INFO – "FrameworkEvent INFO"

101.6.4 Log Events

Log events must be delivered to the Event Admin service 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.

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

Log Service Package 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.66]
- LogListener - Subscribes to LogEntry objects from the LogReaderService. [p.67]
- LogReaderService - Provides methods to retrieve LogEntry objects from the log. [p.67]
- LogService - Provides methods for bundles to write messages to the log. [p.68]

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.68], `LogListener`[p.67]

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.68], `LogService.LOG_WARNING`[p.69], `LogService.LOG_INFO`[p.69], `LogService.LOG_DEBUG`[p.68]

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.67], `LogEntry`[p.66], `LogReaderService.addLogListener(LogListener)`[p.67], `LogReaderService.removeLogListener(LogListener)`[p.68]

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.66]

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.66], `LogListener`[p.67], `LogListener.logged(LogEntry)`[p.67]

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.67], `LogEntry`[p.66], `LogListener.logged(LogEntry)`[p.67]

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.67]

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 ServiceReference 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.68]
2 LOG_WARNING[p.69]
3 LOG_INFO[p.69]
4 LOG_DEBUG[p.68]

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.68], LOG_WARNING[p.69], LOG_INFO[p.69], LOG_DEBUG[p.68]

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.68], LOG_WARNING[p.69], LOG_INFO[p.69], LOG_DEBUG[p.68]

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.68], LOG_WARNING[p.69], LOG_INFO[p.69], LOG_DEBUG[p.68]

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.68] , LOG_WARNING[p.69] , LOG_INFO[p.69] , LOG_DEBUG[p.68]

104 Configuration Admin Service Specification

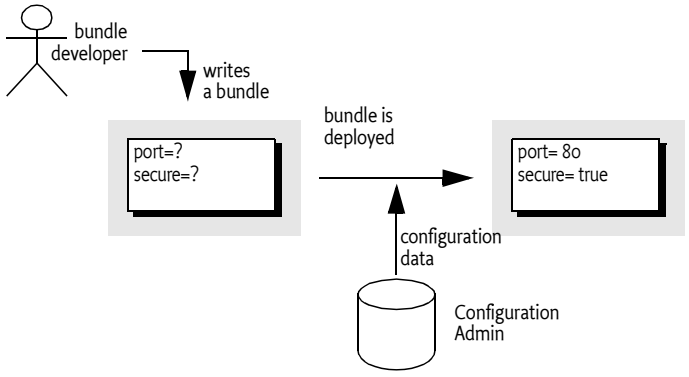
Version 1.2

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 104.1 *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.

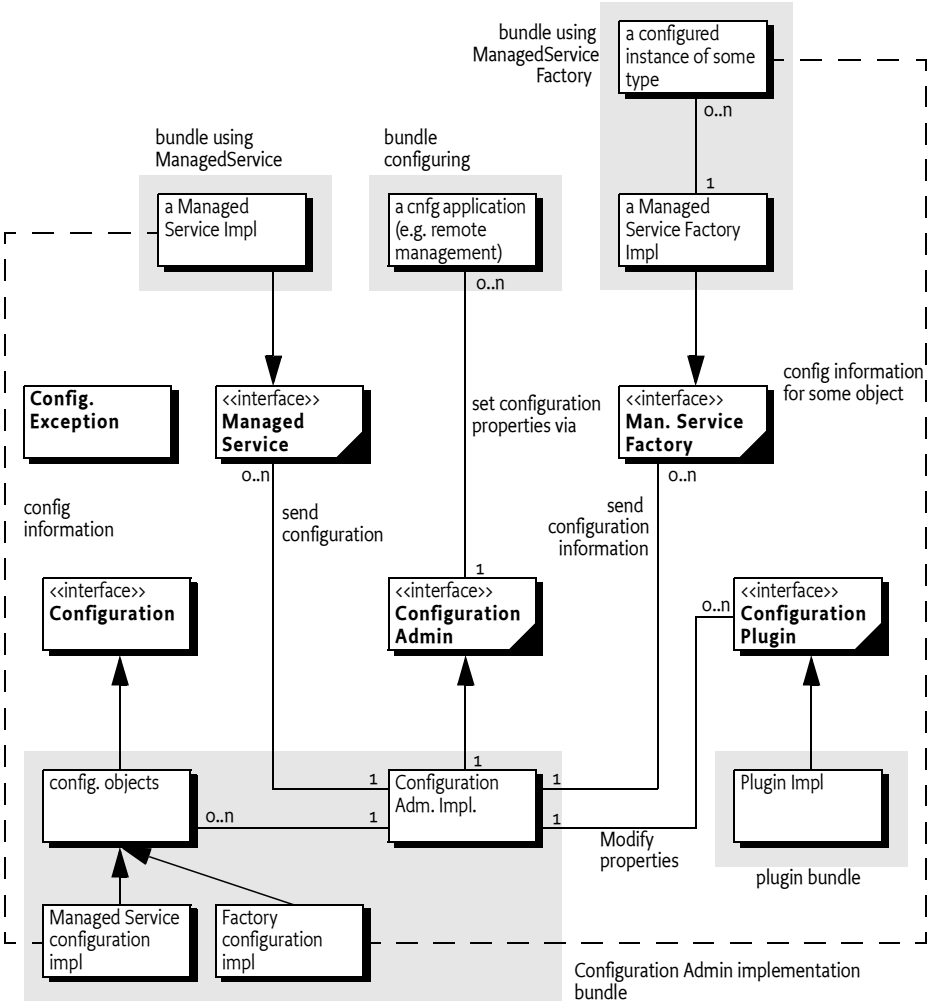
The database can be manipulated either by the Management Agent or bundles that configure themselves.

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.

Figure 104.2 Configuration Admin Class Diagram org.osgi.service.cm



104.2 Configuration Targets

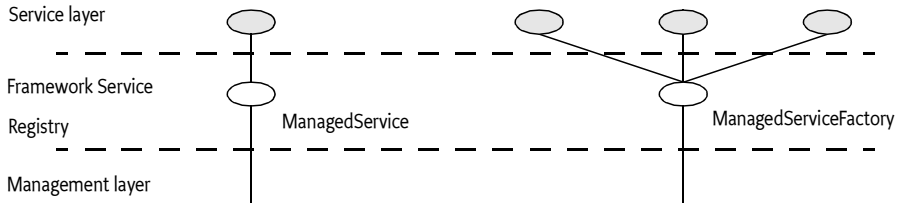
One of the more complicated aspects of this specification is the subtle distinction between the ManagedService and ManagedServiceFactory classes.

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 104.3 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 104.1 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 75 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 should 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 117.

104.4.3 Property Propagation

An implementation of a Managed Service should copy all the properties of the Dictionary object argument 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 91, 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 95.

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

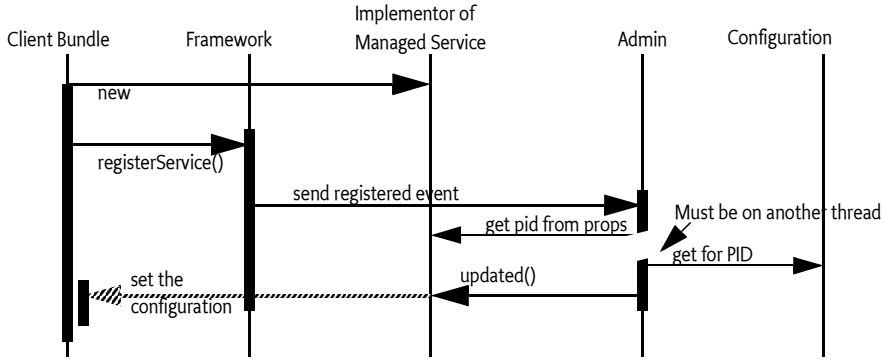
- The configuration stored for the registered PID must be retrieved. If there is a Configuration object for this PID, it is sent to the Managed Service with updated(Dictionary).

- 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 104.4 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

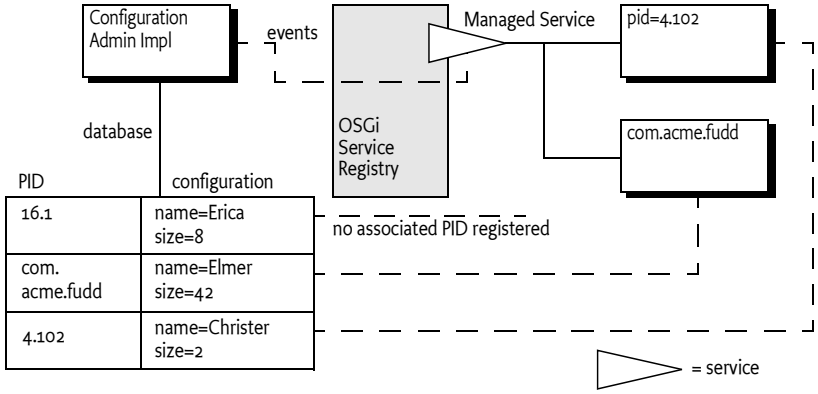
When a Managed Service is registered, the default properties may be visible in the service registry for a short period before they are replaced by the properties of the actual configuration dictionary. Care should be taken that this visibility does not cause race conditions for other bundles.

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

Figure 104.5 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.

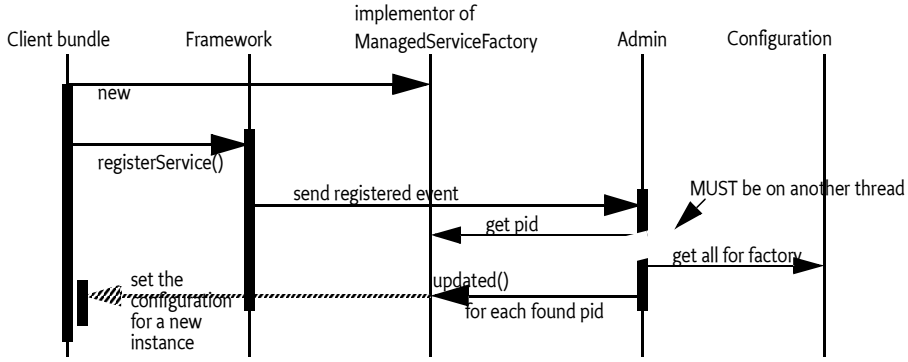
When the Configuration Admin service detects the registration of a Managed Service Factory, it must find all configuration dictionaries for this factory and must then sequentially call ManagedServiceFactory.updated(String,Dictionary) for each configuration dictionary. The first argument is the PID of 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 104.6 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.

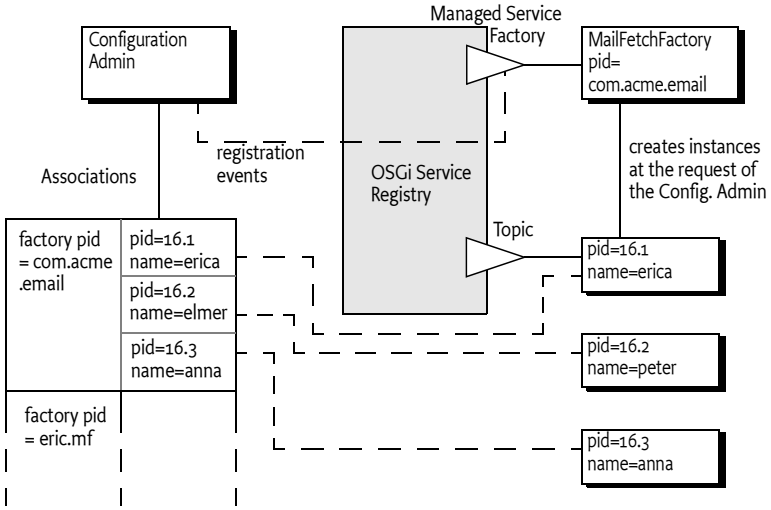
Deletion will asynchronously send out a Configuration Event CM_DELETED to all registered Configuration Listener services.

104.6.4 Managed Service Factory Example

Figure 104.7 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 104.7 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. The way events must be delivered is the same as described in *Delivering Events* on page 92 of the Core specification.

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.

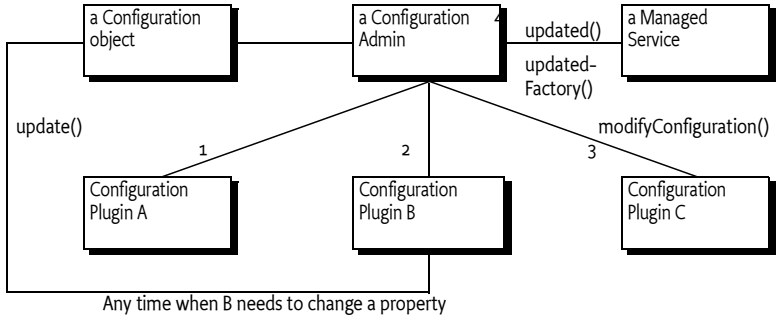
The ConfigurationPlugin interface has only one method: modifyConfiguration(ServiceReference,Dictionary). This method inspects or modifies configuration data.

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 79.

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 104.8 *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 Configuration Plugin 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 104.2 shows the usage of the service.cmRanking property for the order of calling the Configuration Plugin services.

Table 104.2 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 [1] *DMTF Common Information Model* (CIM) and [2] *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 [4] *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 [3] *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 [5] *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 |Configur ationPlugin, 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[Configur ationPlugin, 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 90.
- 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 96.
- The PID is now defined in the Core specification as well
- A property name is now defined as a symbolic-name.
- Event Admin mapping added.

104.15 org.osgi.service.cm

Configuration Admin Package 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.99]
- ConfigurationAdmin - Service for administering configuration data. [p.102]
- ConfigurationEvent - A Configuration Event. [p.105]
- ConfigurationException - An Exception class to inform the Configuration Admin service of problems with configuration data. [p.107]
- ConfigurationListener - Listener for Configuration Events. [p.108]
- ConfigurationPermission - Indicates a bundle's authority to configure bundles. [p.108]
- ConfigurationPlugin - A service interface for processing configuration dictionary before the update. [p.109]
- ManagedService - A service that can receive configuration data from a Configuration Admin service. [p.111]
- ManagedServiceFactory - Manage multiple service instances. [p.112]

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 intiates 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 updated 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 intiates 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 initate 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.109]

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.112] 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 Confguration 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 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.101] 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.101] 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.106]
- CM_DELETED[p.106]

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.108]

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.107] .

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.106]
  - CM_DELETED[p.106]

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 <= service.cmRanking <= 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 identitifier 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.107] 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

[1] *DMTF Common Information Model*
http://www.dmtf.org

[2] *Simple Network Management Protocol*
RFCs http://directory.google.com/Top/Computers/Internet/Protocols/SNMP/RFCs

[3] *XSchema*
http://www.w3.org/TR/xmlschema-0/

[4] *Interface Definition Language*
http://www.omg.org

[5] *Lightweight Directory Access Protocol*
http://directory.google.com/Top/Computers/Software/Internet/Servers/Directory/LDAP

[6] *Understanding and Deploying LDAP Directory services*
Timothy Howes et. al. ISBN 1-57870-070-1, MacMillan Technical publishing.

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 *metadata*.

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 71. 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.

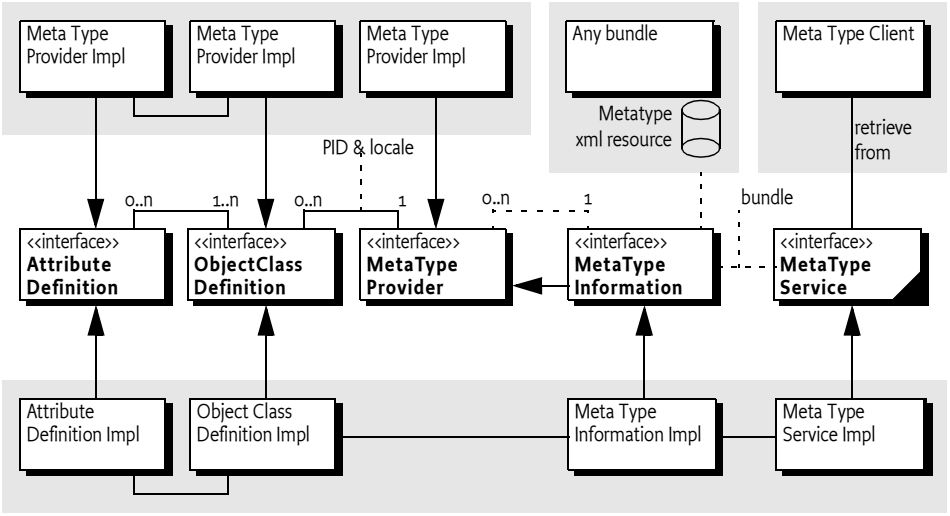
105.1.1 Essentials

- *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 105.1 Class Diagram Meta Type Service, org.osgi.service.metatype



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 requests the Meta Type Information associated with a particular bundle. The MetaTypeInformation 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 [2] *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:

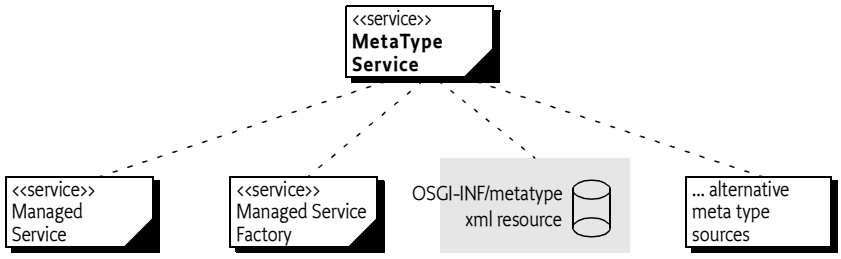
- Defined names (final ints) for the data types as restricted in the Framework for the attributes, called the syntax in OSI terms, which can be obtained with the getType() method.
- AttributeDefinition objects should use and ID that is similar to the OID as described in the ID field for ObjectClassDefinition.
- 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 ore 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 105.2 Sources for Meta Types



This model is depicted in Figure 105.2.

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:

- getMetaTypeInformation(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 MetaTypeInformation 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 MetaTypeInformation object with the following methods:

- getPids() – PIDs for which Meta Types are available.
- getFactoryPids() – PIDs associated with Managed Service Factory services.

These methods and their interaction with the Meta Type resource are described in *Use of the Designate Element* on page 128.

The MetaTypeInformation 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 MetaTypeInformation 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 ) {
  MetaTypeInformation mti =
    mts.getMetaTypeInformation(b);
  String [] pids = mti.getPids();
  String [] locales = mti.getLocales();

  for ( int locale = 0; locale<locales.length; locale++ ) {
    System.out.println("Locale " + locales[locale] );
    for (int i=0; i< pids.length; i++) {
      ObjectClassDefinition ocd =
        mti.getObjectClassDefinition(pids[i], null);
      AttributeDefinition[] ads =
        ocd.getAttributeDefinitions(
          ObjectClassDefinition.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 directory. 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. A 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 62, 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 MetaTypeInformation.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:

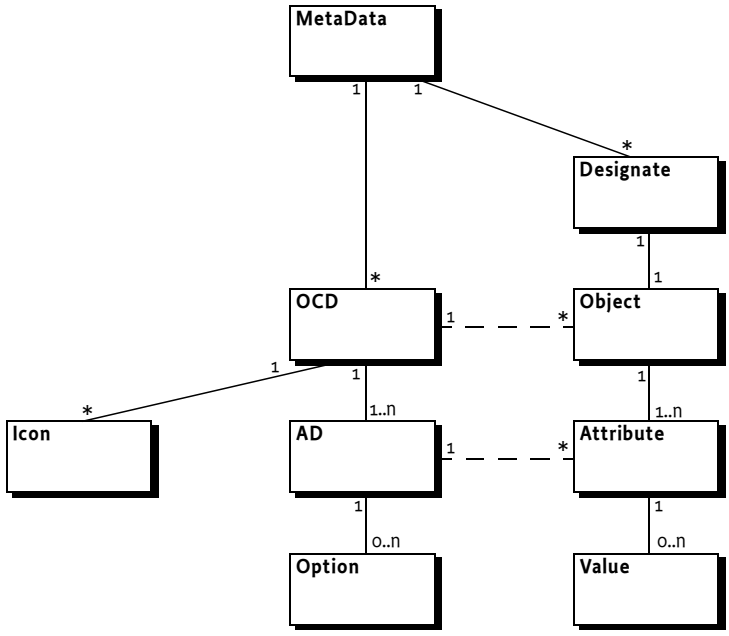
```
http://www.osgi.org/xmlns/metatype/v1.0.0
```

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 105.3 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 105.1.

Table 105.1 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 *Localization* on page 62 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, cannot be localized.
Designate				An association between one PID and an Object Class Definition. This element *designates* a PID to be of a certain *type*.
pid	<>	string		The PID that is associated with an OCD. This can be a reference to a factory or singleton configuration object. See *Use of the Designate Element* on page 128.
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. See *Use of the Designate Element* on page 128.

Table 105.1 XML Schema for Meta Type resources

	Attribute	Deflt	Type	Method	Description
	bundle		string		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. In a Meta Type resource this field may be set to an wildcard (\u002A, "*") to indicate the bundle where the resource comes from. This is an optional attribute but can be mandatory in certain usage schemes, like for example the Autoconf Resource Processor.
	optional	false	boolean		If true, then this Designate element is optional, errors during processing must be ignored.
	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: String ↔ STRING Long ↔ LONG Double ↔ DOUBLE Float ↔ FLOAT Integer ↔ INTEGER Byte ↔ BYTE Char ↔ CHARACTER Boolean ↔ BOOLEAN Short ↔ SHORT
	cardinality	0		getCardinality()	The number of elements an instance can take. Positive numbers describe an array ([]) and negative numbers describe a Vector object.

Table 105.1 XML Schema for Meta Type resources

	Attribute	Deflt	Type	Method	Description
	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.

	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:
					`dflt="a\,b,b\,c, c\\,d"`
					`=> [ "a,b", "b,c", "c\", "d" ]`

	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.

Table 105.1 XML Schema for Meta Type resources

Attribute	Deflt	Type	Method	Description
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 127.
Value				Holds a single value. This element can be repeated multiple times under an Attribute

105.6.2 Use of the Designate Element

For the MetaType Service, the Designate definition is used to declare the available PIDs and factory PIDs; the Attribute elements are never used by the MetaType service.

The getPids() method returns an array of PIDs that were specified in the pid attribute of the Object elements. The getFactoryPids() method returns an array of the factoryPid attributes. For factories, the related pid attribute is ignored because all instances of a factory must share the same meta type.

The following example shows a metatype reference to a singleton configuration and a factory configuration.

```
<Designate pid="com.acme.designate.1">
   <Object ocdref="com.acme.designate"./>
</Designate>
<Designate factoryPid="com.acme.designate.factory"
   bundle="*">
   <Object ocdref="com.acme.designate"/>
</Designate>
```

Other schemes can embed the Object element in the Designate element to define actual instances for the Configuration Admin service. In that case the pid attribute must be used together with the factoryPid attribute. However, in that case an aliasing model is required because the Configuration Admin service does not allow the creator to choose the Configuration object's PID.

105.6.3 Example Meta Data File

This example defines a meta type file for a Person record, based on ISO attribute types. The ids that are used are derived from ISO attributes.

```
<?xml version="1.0" encoding="UTF-8"?>
<MetaData
   xmlns=
      "http://www.osgi.org/xmlns/metatype/v1.0.0"
    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 ocdref="2.5.6.6"/>
  </Designate>
 </MetaData>
```

Translations for this file, as indicated by the localization attribute must be stored in the OSGI-INF/l10n directory (e.g. OSGI-INF/l10n/person_du_NL.properties). The default localization root for the properties is OSGi-INF/bundle, but can be overridden by the Manifest localization Bundle-Localization header). 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=Personne
person\ record=Description de la personne
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.

For example:

```
<Designate pid="com.acme.b">
   <Object ocdref="b">
      <Attribute adref="foo" content="Zaphod Beeblebrox"/>
      <Attribute adref="bar">
         <Value>1</Value>
         <Value>2</Value>
         <Value>3</Value>
         <Value>4</Value>
         <Value>5</Value>
      </Attribute>
   </Object>
  </Designate>
```

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">
        <sequence>
            <element name="Value" type="string" minOccurs="0"
                maxOccurs="unbounded" />
        </sequence>
        <attribute name="adref" type="string" use="required" />
        <attribute name="content" type="string" use="optional" />
    </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" />
        <attribute name="bundle" type="string" use="optional" />
        <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 121.
- A standardized XML schema to define Metatypes as well as related instances. See *XML Schema* on page 130.

105.13 org.osgi.service.metatype

Metatype Package 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.133]
- MetaTypeInformation - A MetaType Information object is created by the MetaTypeService to return meta type information for a specific bundle. [p.136]
- MetaTypeProvider - Provides access to metatypes. [p.136]
- MetaTypeService - The MetaType Service can be used to obtain meta type information for a bundle. [p.137]
- ObjectClassDefinition - Description for the data type information of an objectclass. [p.137]

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 BigDecimal, Vector with BigDecimal or BigDecimal[] objects depending on getCardinality().

Deprecated As of 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 As of 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:

```
    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
```

Returns The cardinality of this attribute.

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.

Returns 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 MetaTypeInformation 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 ObjectClassDefinition 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 MetaTypeInformation object.

If the specified bundle does not contain any meta type documents, then a MetaTypeInformation 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 MetaTypeInformation getMetaTypeInformation(Bundle bundle)

bundle The bundle for which meta type information is requested.

□ Return the MetaType information for the specified bundle.

Returns A MetaTypeInformation 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

[1] *LDAP.*
Available at http://directory.google.com/Top/Computers/Software/Internet/Servers/Directory/LDAP

[2] *Understanding and Deploying LDAP Directory services*
Timothy Howes et. al. ISBN 1-57870-070-1, MacMillan Technical publishing.

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 [1] *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.

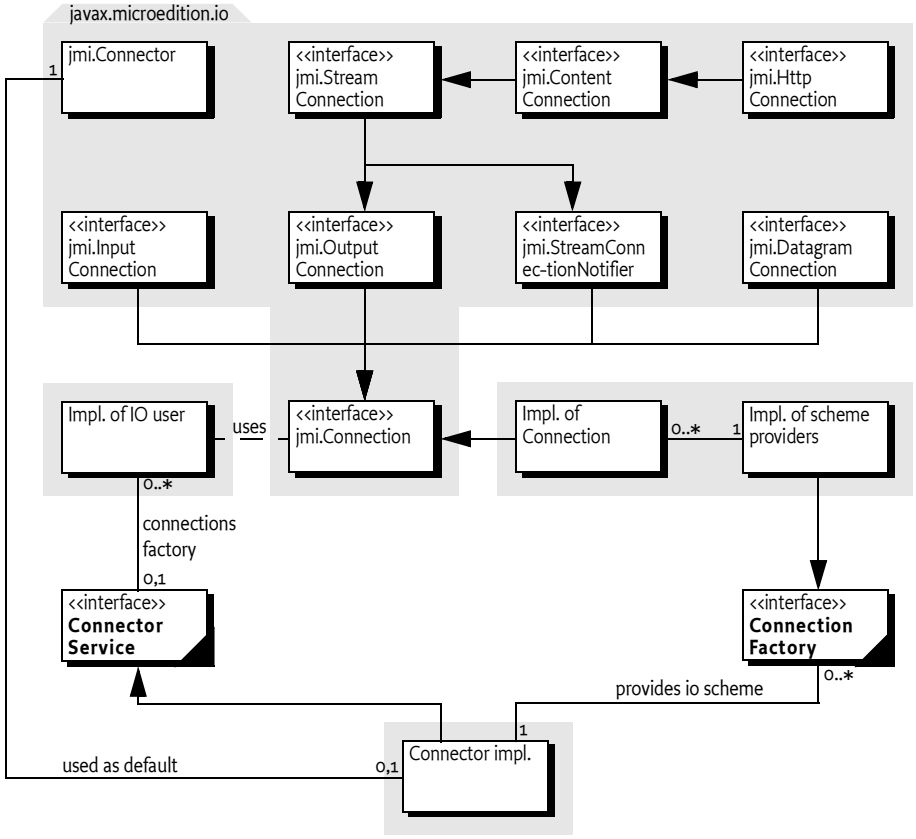
109.1.1 Essentials

- *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.microediton.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 109.1 Class Diagram, org.osgi.service.io (jmi is javax.microedition.io)



109.2 The Connector Framework

The [1] *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 Connection Factory service. The remainder of the URI may contain parameters that are used by the Connection Factory 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

IO Connector Package 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.micro-
edition.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.145]
- ConnectorService - The Connector Service should be called to create and open javax.microedition.io.Connection objects. [p.147]

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.147] 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 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

[1] *Java 2 Micro Edition*
http://java.sun.com/j2me/

[2] *javax.microedition.io whitepaper*
http://wireless.java.sun.com/midp/chapters/j2mewhite/chap13.pdf

[3] *J2ME Foundation Profile*
http://www.jcp.org/jsr/detail/46.jsp

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 [1] *Automating Service Dependency Management in a Service-Oriented Component Model*.

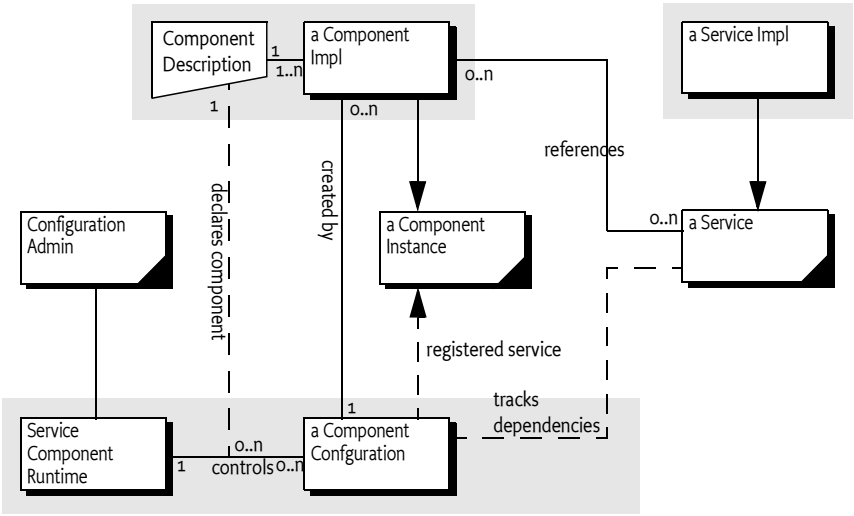
112.1.1 Essentials

- *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 112.1 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 154, 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 168 provides some deeper insight in the life cycle of components.
- *Service Programmers* – Service programmers should read *Components* on page 154. This chapter should suffice for the most common cases. For the more advanced possibilities, they should consult *Component Description* on page 163 for the details of the XML grammar for component descriptions.
- *Deployers* – Deployers should consult *Deployment* on page 176.

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 163. The XML grammar for the component declaration is defined by the XML Schema, see *Component Description Schema* on page 178.

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 normal 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">some/topic</property>
   <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 175. 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 172.

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="HTTP"
      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="HTTP"
      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 175 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 178 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> *
```

SCR must not require component descriptions to specify the elements in the order listed above and as required by the XML schema. SCR must allow other orderings since arbitrary orderings of these elements do not affect the meaning of the component description. Only the relative ordering of property and properties element have meaning.

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 176 for more information. The XML schema allows the use of component names which are not valid PIDs. Care must be taken to use a valid PID for a component name if the component should be configured by the Configuration Admin service.
- 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 168.

- 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 156.
- 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 175 and *Deployment* on page 176.

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. If this method is not available for the given type, the conversion must be done according to the corresponding method in Java 2 SE. For Character types, the conversion is handled by Integer.valueOf method.
- 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
  - Character
  - 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 [3] *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 160.
- policy – The policy declares the assumption of the component about dynamicity. See *Reference Policy* on page 161.
- 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 162.
- 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 158.

- unbind – Same as bind, but is used to notifiy 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 158.

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 164. 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:

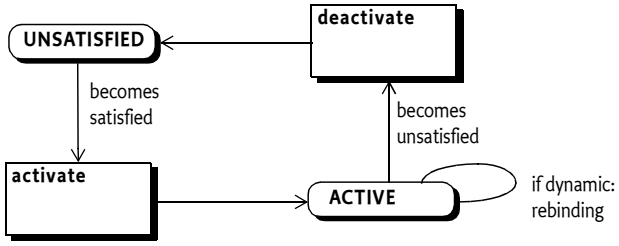
- The component is *enabled*.
- Using the component properties of the component configuration, all the component's references are satisfied. A reference is satisfied when the reference specifies optional cardinality or there is at least one target service for the reference.

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 112.2.

Figure 112.2 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 175.

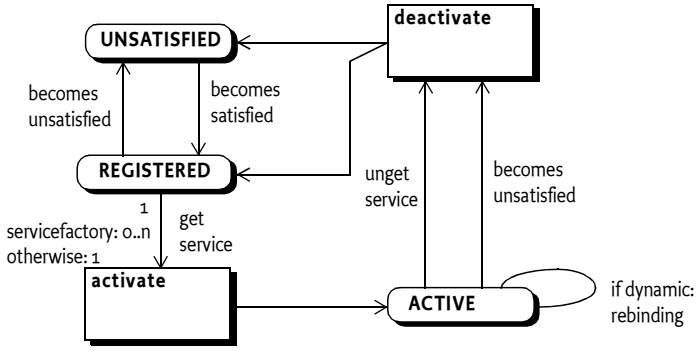
The activation of a component configuration must be delayed until its service is requested. When the service is requested, if the service has the servicefactory attribute set to true, SCR must create and activate a unique component configuration for each bundle requesting the service. Other-

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 112.3. 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 112.3 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.

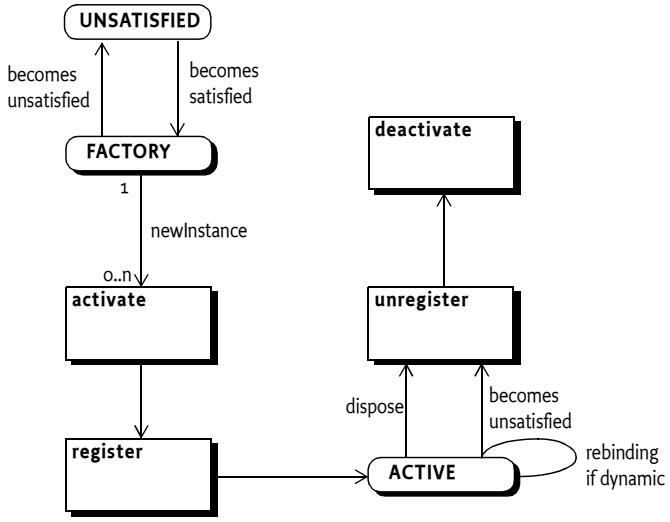
The Component Factory service must be registered under the name org.osgi.service.component.ComponentFactory with the following service properties:

- 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 175. The service registration must take place before the component configuration is activated. Service unregistration must take place before the component configuration is deactivated.

Figure 112.4 *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 172.
4 Call the activate method, if present. See *Activate Method* on page 172.

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 160.

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 173.
2 Unbind any bound services. See *Unbinding* on page 174.
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:

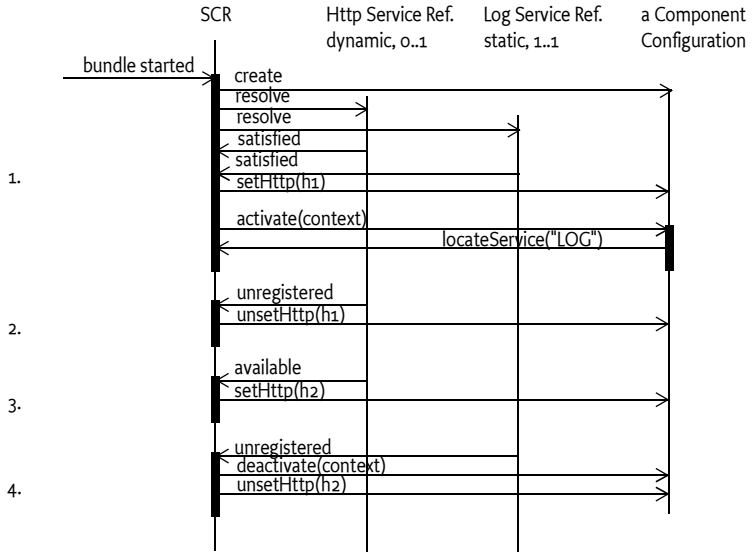
```
public class Binding {
   LogService  log;
   HttpService http;

   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 112.5. 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 112.5 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 162.
   - property and properties elements – See *Properties and Property Elements* on page 165.

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 cannot 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>
```

```
    <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>
```

SCR must not require component descriptions to specify the elements in the order required by the schema. SCR must allow other orderings since arbitrary orderings of these elements do not affect the meaning of the component description. Only the relative ordering of `property` and `properties` element have meaning.

112.11 org.osgi.service.component

Service Component Package 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.180]
- ComponentContext - A Component Context object is used by a component instance to interact with its execution context including locating services by reference name. [p.181]
- ComponentException - Unchecked exception which may be thrown by the Service Component Runtime. [p.183]
- 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.184]
- ComponentInstance - A ComponentInstance encapsulates a component instance of an activated component configuration. [p.184]

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 optionaly 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 optionaly 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 or null if there are no additional properties.

- 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

[1] *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

[2] *Service Binder*
Humberto Cervantes, Richard S. Hall, http://gravity.sourceforge.net/servicebinder

[3] *Java Properties File*
http://java.sun.com/j2se/1.4.2/docs/api/java/util/Properties.html#load(java.io.InputStream)

113 Event Admin Service Specification

Version 1.1

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

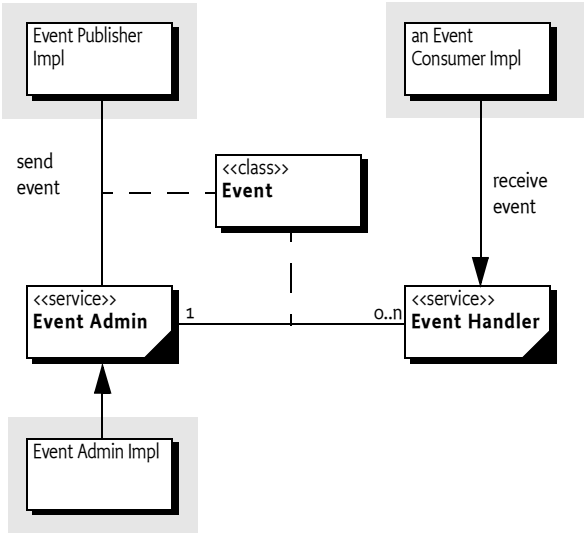
- *Simplifications* – The model must significantly simplify the process of programming an event source and an event handler.
- *Dependencies* – Handle the myriad of dependencies between event sources and event handlers for proper cleanup.
- *Synchronicity* – It must be possible to deliver events asynchronously 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 113.1 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

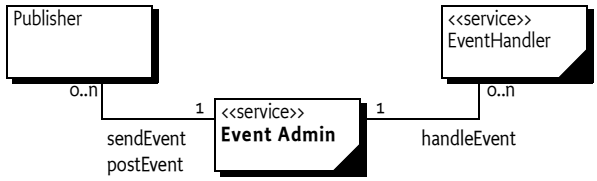
- *Architects* – The *Event Admin Architecture* on page 189 provides an overview of the Event Admin service.

- *Event Publishers* – The *Event Publisher* on page 191 provides an introduction of how to write an Event Publisher. The *Event Admin Architecture* on page 189 provides a good overview of the design.
- *Event Subscribers/Handlers* – The *Event Handler* on page 190 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 113.2.

Figure 113.2 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 have not specified the EVENT_TOPIC service 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 BundleActivator,
     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_TOPIC, 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();

    ServiceTrackertracker;

    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 {
          Calendarc = Calendar.getInstance();
          set(c,Calendar.MINUTE,"minutes");
          set(c,Calendar.HOUR,"hours");
          set(c,Calendar.DAY_OF_MONTH,"day");
          set(c,Calendar.MONTH,"month");
          set(c,Calendar.YEAR,"year");

          EventAdminea = (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 113.1..

Table 113.1 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.
EXECPTION_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 – (ServiceEvent) The original Service 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.

113.7 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. This is the same as described in *Delivering Events* on page 92 of the Core specification.

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 deadlocked 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 Changes

- Corrected spelling of EXCEPTION_CLASS constant by adding new constant with the proper spelling and deprecating the misspelled constant.
- Added BUNDLE_ID and BUNDLE constants.

113.12 org.osgi.service.event

Event Admin Package 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.event; version=1.1
```

113.12.1 Summary

- Event - An event. [p.199]
- EventAdmin - The Event Admin service. [p.200]
- EventConstants - Defines standard names for EventHandler properties. [p.200]
- EventHandler - Listener for Events. [p.202]
- TopicPermission - A bundle's authority to publish or subscribe to event on a topic. [p.203]

113.12.2 public class Event

An event. Event objects are delivered to EventHandler services which subsrcibe to the topic of the event.

113.12.2.1 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.

113.12.2.2 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.

113.12.2.3 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.

113.12.2.4 public final String[] getPropertyNames( )

- Returns a list of this event's property names.

Returns A non-empty array with one element per property.

113.12.2.5 public final String getTopic( )

- Returns the topic of this event.

Returns The topic of this event.

113.12.2.6 public int hashCode( )

- Returns a hash code value for the object.

Returns An integer which is a hash code value for this object.

113.12.2.7 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.

113.12.2.8 public String toString( )

- Returns the string representation of this event.

Returns The string representation of this event.

113.12.3 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.

113.12.3.1 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.

113.12.3.2 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.

113.12.4 public interface EventConstants

Defines standard names for EventHandler properties.

113.12.4.1 public static final String BUNDLE = "bundle"

The Bundle object of the bundle relevant to the event.

Since 1.1

113.12.4.2 public static final String BUNDLE_ID = “bundle.id”

The Bundle id of the bundle relevant to the event.

Since 1.1

113.12.4.3 public static final String BUNDLE_SIGNER = “bundle.signer”

The Distinguished Name of the bundle relevant to the event.

113.12.4.4 public static final String BUNDLE_SYMBOLICNAME = “bundle.symbolicName”

The Bundle Symbolic Name of the bundle relevant to the event.

113.12.4.5 public static final String EVENT = “event”

The actual event object. Used when rebroadcasting an event that was sent via some other event mechanism.

113.12.4.6 public static final String EVENT_FILTER = “event.filter”

Service Registration property (named event.filter) specifying a filter to further select Event s 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.199], `org.osgi.framework.Filter`

113.12.4.7 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 must not receive events. 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.199]

113.12.4.8 public static final String EXCEPTION = “exception”

An exception or error.

113.12.4.9 public static final String EXCEPTION_CLASS = “exception.class”

Must be equal to the name of the Exception class.

Since 1.1

113.12.4.10 **public static final String EXCEPTION_MESSAGE = “exception.message”**

Must be equal to exception.getMessage()

113.12.4.11 **public static final String EXECPTION_CLASS = “exception.class”**

This constant was released with an incorrect spelling. It has been replaced by EXCEPTION_CLASS[p.201]

Deprecated As of 1.1, replaced by EXCEPTION_CLASS

113.12.4.12 **public static final String MESSAGE = “message”**

A human-readable message that is usually not localized.

113.12.4.13 **public static final String SERVICE = “service”**

A service

113.12.4.14 **public static final String SERVICE_ID = “service.id”**

A service’s id.

113.12.4.15 **public static final String SERVICE_OBJECTCLASS = “service.objectClass”**

A service’s objectClass

113.12.4.16 **public static final String SERVICE_PID = “service.pid”**

A service’s persistent identity.

113.12.4.17 **public static final String TIMESTAMP = “timestamp”**

The time when the event occurred, as reported by System.currentTimeMillis()

113.12.5 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.201] whose value is the list of topics in which the event handler is interesed.

For example:

```
String[] topics = new String[] {EventConstants.EVENT_TOPIC,
“com/isv/*”};
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 EventConstants.EVENT_FILTER[p.201] service propery 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.199]

113.12.5.1 public void handleEvent(Event event)

event The event that occurred.

- Called by the EventAdmin[p.200] service to notify the listener of an event.

113.12.6 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.

113.12.6.1 public static final String PUBLISH = "publish"

The action string publish.

113.12.6.2 public static final String SUBSCRIBE = "subscribe"

The action string subscribe.

113.12.6.3 public TopicPermission(String name, String actions)

name Topic name.

actions publish,subscribe (canonical order).

- Defines the authority to publich 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.

113.12.6.4 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.

113.12.6.5 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.

113.12.6.6 public int hashCode( )

- Returns the hash code value for this object.

Returns A hash code value for this object.

113.12.6.7 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.

113.12.6.8 public PermissionCollection newPermissionCollection( )

- Returns a new PermissionCollection object suitable for storing TopicPermission objects.

Returns A new PermissionCollection object.

114 Deployment Admin Specification

Version 1.0

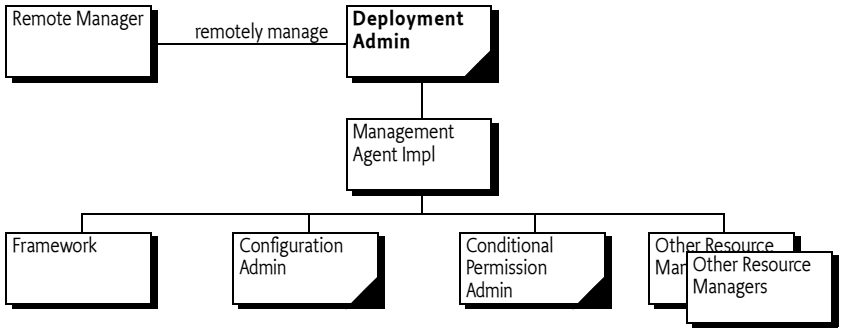
114.1 Introduction

The ability to install new software components after the time of manufacture is of increasing interest to manufacturers, operators, and end users. End users already are, or soon will be, accustomed to installing applications or services on their devices from remote servers.

The OSGi Service Platform provides mechanisms to manage the lifecycle of bundles, configuration objects, and permission objects, but the overall consistency of the runtime configuration is the responsibility of the *management agent*. In other words, the management agent decides to install, update, or uninstall bundles, create or delete configuration or permission objects, and manage other resource types.

The task of the management agent is extensive because it must track the sometimes fine-grained dependencies and constraints between the different resource types. This model, though extremely flexible, leaves many details up to the implementation—significantly hindering the interoperability of devices because it does not unify the management aspects from the management systems point of view. This specification, therefore, introduces the *Deployment Admin service* that standardizes the access to some of the responsibilities of the management agent: that is, the lifecycle management of interlinked resources on an OSGi Service Platform.The role of the Deployment Admin service is depicted in Figure 114.1.

Figure 114.1 Deployment Admin role



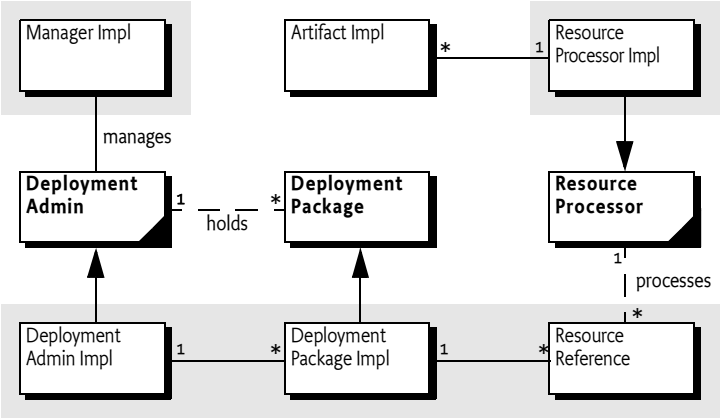
114.1.1 Essentials

- *Installing/Uninstalling* – Provide a Deployment Package concept to install and uninstall bundles and related resources on an OSGi Service Platform as an atomic unit.
- *Tamper Detection* – Provide detection of changes to a Deployment Package.
- *Securing* – Provide a security model that allows Operators to control the Deployment Packages that are installed on an OSGi Service Platform.
- *Media Independence* – Deployment Packages must have the capacity to load from different media such as CD-ROM, over the air, wireless, etc.
- *Management* – Management of a repository of Deployment Packages must be possible locally on the device as well as remotely.
- *Customizing* – The author of a Deployment Package must be permitted to customize the environment during the installation and uninstallation operations.
- *Extending* – The resource types that are used in a Deployment Package must be easy to extend.

114.1.2 Entities

- *Resource* – A file in a Deployment Package that is processed to create artifacts in the Service Platform. For example, bundles, configurations, and permissions are different resources.
- *Deployment Admin Service* – The service that is used to install and uninstall Deployment Packages, as well as to provide information about the repository of Deployment Packages.
- *Resource Processor* – A service that can handle the lifecycle of a specific resource type. It processes a resource to create a number of artifacts that are removed when the resource is dropped.
- *Deployment Package* – A group of resources that must be treated as a unit. Unbreakable dependencies exist among these resources.
- *Artifact* – A construct that is created from a Resource in a Deployment Package. A resource can have zero or more artifacts related to it. Artifacts do not have a common interface because their nature differs and their existence is abstracted by the Resource Processor services. Artifacts must be removed when their related resources are dropped. An example of an artifact is a Configuration object that is created from an configuration file in a Deployment Package.
- *Customizer* – A bundle carried in a Deployment Package that can perform initialization during an install operation and cleanup during an uninstall operation.
- *Fix Package* – A Deployment Package that is an update to an resident Deployment Package, which does not carry some resources because they are unchanged.

Figure 114.2 Deployment Admin Service, org.osgi.service.deploymentadmin package



114.1.3 Synopsis

A developer can package a number of resources in a Deployment Package. A Deployment Package is stored in a JAR file, with a format that is similar to bundles. A Deployment Package JAR can be installed via the Deployment Admin service via an input stream. The Deployment Admin service manages the bundle resources itself, but processes every other resource in the Deployment Package by handing them off to a Resource Processor service that is designated for that resource. The Resource Processor service will then process the resource to create a number of artifacts.

The uninstallation and update of a Deployment Package works in a similar manner. All Resource Processor services are notified about any resources that are dropped or changed.

If all resources have been processed, the changes are committed. If an operation on the Deployment Admin service fails, all changes are rolled back. The Deployment Admin service is not, however, guaranteed to support all features of transactions.

114.2 Deployment Package

A Deployment Package is a set of related *resources* that need to be managed as a *unit* rather than individual pieces. For example, a Deployment Package can contain both a bundle and its configuration data. The resources of a Deployment Package are tightly coupled to the Deployment Package and cannot be shared with other Deployment Packages.

A Deployment Package is not a script that brings the system from one consistent state to another; several deployment packages may be needed to achieve a new consistent state. Like a bundle, a Deployment Package does not have to be self-contained. Its bundle resources can have dependencies on Java packages and services provided by other Deployment Packages.

For example, a suite of games shares some parts that are common to both games. The suite contains two games: Chess (com.acme.chess) and Backgammon (com.acme.backg). Both share a top-score database as well as a 3D graphic library.

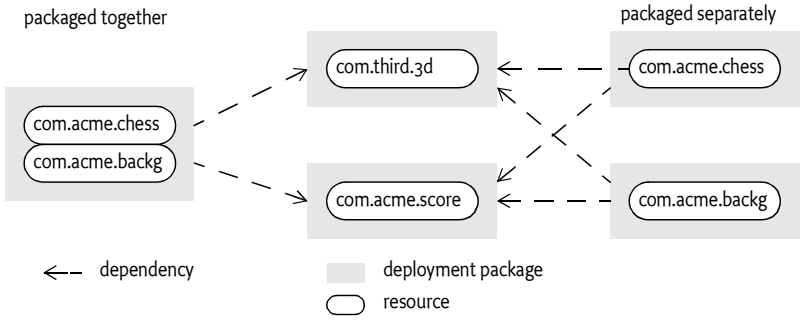
- com.third.3d – The 3D graphic library comes from a third-party provider. It is a Deployment Package of its own, composed of several bundles and possible configuration objects.
- com.acme.score – The top-score database would also be its own Deployment Package, and would in fact be optional. It offers a service for storing top scores, but games can function without this service.

Each game is a Deployment Package, allowing them to be installed independently. Alternatively, the two games can be packaged into the same Deployment Package, but in this case they must be installed and removed together and can no longer be deployed independently.

These two different packaging strategies cannot be used simultaneously. Once the games are deployed separately, they can no longer be grouped later in an update, because that action would move ownership of the bundle resource to another Deployment Package—which is specifically not allowed. A bundle resource can belong to only one Deployment Package.

These two packaging scenarios are depicted in Figure 114.3.

Figure 114.3 Packaged game



Deployment Packages are managed as *first-class citizens* during runtime, similar to bundles. The DeploymentPackage object represents this concept in runtime.

114.2.1 Resources

A Deployment Package consists of installable *resources*. Resources are described in the *Name sections* of the Manifest. They are stored in the JAR file under a path. This path is called the *resource id*.

Subsets of these resources are the bundles. Bundles are treated differently from the other resources by the Deployment Admin service. Non-bundle resources are called *processed resources*.

Bundles are managed by the Deployment Admin service directly. When installing a new bundle, the Deployment Admin service must set the bundle location to the following URL:

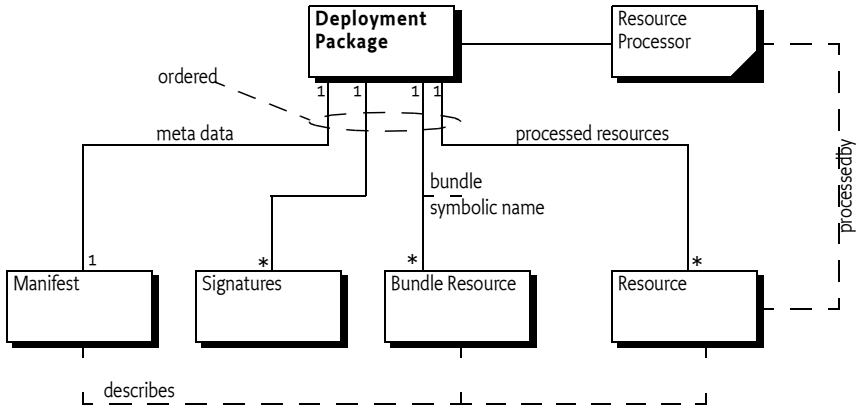
```
location  ::= 'osgi-dp:' bsn
```

```
bsn          ::= unique-name      // See 1.4.2 Core
```

The bsn stands for the bundle's Bundle Symbolic Name, without any parameters, which implies that only a single version of a bundle can be installed at any moment in time. The osgi-dp: scheme is not required to have a valid URL handler.

Processed resources are not managed directly by the Deployment Admin service; their management must be handed off to a Resource Processor service that is selected in the Name section. The logical structure and processing of resources is depicted in Figure 114.4.

Figure 114.4 Structure of a Deployment Package



114.2.2 Atomicity and Sharing

A Deployment Package is a reified concept, like a bundle, in an OSGi Service Platform. It is created and managed by the Deployment Admin service. As a unit, a Deployment Package should be installed or uninstalled atomically.

Deployment packages provide an ownership model for resources installed in an OSGi Service Platform. A Deployment Package contains resources, which once processed, will result in the creation of a number of artifacts in the OSGi Platform such as:

- Installed bundles
- Configuration objects
- System properties
- Certificates
- Wiring schemes

A Deployment Package will *own* its resources. If a Deployment Package is uninstalled, all its resources, and thus its artifacts, must be removed as well. The ownership model follows a *no-sharing* principle: equal resources are not shared between deployment packages.

The meaning of "equal" is dependent on the resource type. For example, two bundles are considered equal if their bundle symbolic name is equal, regardless of the version.

A sharing violation must be considered an error. The install or update of the offending Deployment Package must fail if a resource would be affected by another Deployment Package. The verification of this rule is delegated to the Resource Processor services, or the Deployment Admin service in case of bundles.

For example, a Deployment Package could be used to install bundles and configuration objects for Managed Services (singleton configurations). Because of the no-sharing principle, an installed bundle must belong to one—and only one—Deployment Package (as defined by its Bundle Symbolic Name). A singleton configuration can be set only when the associated bundle is in the same Deployment Package. Trying to install a Deployment Package when one of the bundles or one of the configuration objects is already present and associated with another Deployment Package is an error, and the install must fail in such a case.

This strong no-sharing rule ensures a clean and robust lifecycle. It allows the simple cleanup rule: the Deployment Package that installs a resource is the one that must uninstall it.

114.2.3 Naming

Every Deployment Package must have a name and a version. Package authors should use unique reverse domain naming, like the naming used for Java packages. The version syntax must follow the rules defined in *Version* on page 28 in [2] *OSGi Service Platform Core Specification*; the version must be specified.

The name is set with a Manifest header. This name is used to detect whether an install is an update (an Deployment Package has the given name) or an install (no such Deployment Package exists). The name must be compared in a case-sensitive manner.

Together, the name and version specify a unique Deployment Package; a device will consider any Deployment Package with the same name and version pairs to be identical. Installing a Deployment Package with a name version identical to the existing Deployment Package must not result in any actions.

Deployment packages with the same name but different versions are considered to be *versions* of the *same* deployment package. The Deployment Admin service maintains a repository of installed Deployment Packages. This set must not contain multiple versions of the same Deployment Package. Installing a deployment package when a prior or later version was already present must cause replacement of the existing deployment package. In terms of version, this action can be either an upgrade or downgrade.

114.3 File Format

A Deployment Package is a standard JAR file as specified in [1] *JAR File Specification*. The extension of a Deployment Package JAR file name should be `.dp`. The MIME type of a Deployment Package JAR should be:

```
application/vnd.osgi.dp
```

For example, valid Deployment Package JAR names are:

```
com.acme.chess.dp
chess.dp
```

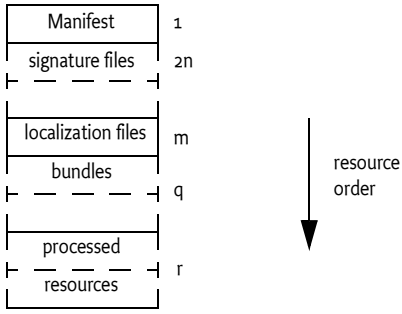
A Deployment Package must be formed in such a way that it can be read with a JarInputStream object. Therefore, the order of the files in the JAR file is important. The order must be:

1 META-INF/MANIFEST.MF – A Deployment Package must begin with a standard Java Manifest file. This rule is not explicitly defined in the Java JAR file specification; it is implied, however, by the known JarInputStream class implementations.
2 META-INF/*.SF, META-INF/*.DSA, META-INF/*.RS – If the Deployment Package is signed, subsequent files in the JAR must be the signature files as defined in the manifest specification. The signature files are not considered resources. Signing is discussed in *Signing* on page 212.
3 *Localization files* – Any manifest localization files are normally stored in the OSGI-INF directory. Localization files must precede the other files because the resource processors can require localized information.
4 *Bundles* must come before any other resource types so that they can be installed before any processed resources.
5 *Resources* – Any processed resources needed for this package. Resources are processed in the order in which they appear in the JAR file, and dropped in reverse order.

The order of all the resources in the JAR file is significant, and is called the *resource order*. The purpose of the resource order is to allow the JAR to be processed as a stream. It is not necessary to buffer the input stream in memory or to hard disk, or to allow random access to its contents. The specification allows access to the stream sequentially. To increase the determinism, the resource order must also determine the processing order of the bundles and the resources.

The format is shown graphically in Figure 114.5.

Figure 114.5 Deployment Package JAR format



114.3.1 Signing

Deployment packages are optionally signed by JAR signing, compatible with the operation of the standard java.util.jar.JarInputStream class, i.e. as defined in *JAR Structure and Manifest* on page 13 of [2] *OSGi Service Platform Core Specification*. This compatibility requires that the manifest must be the first file in the input stream, and the signature files must follow directly thereafter.

A Deployment Package must follow the same rules for signing as bundles, described in the Framework specification, *Digitally Signed JAR Files* on page 12 in [2] *OSGi Service Platform Core Specification*.

The Deployment Admin service must reject a Deployment Package that has an invalid signature.

114.3.2 Path Names

Path names must be limited to remove some of the unnecessary complexities that are caused by path names that can contain any Unicode character. Therefore, a path name must not contain any character except:

```
[A-Za-z0-9_.-]
```

Directories are separated by a forward slash character ('/' \u002F).

114.3.3 Deployment Package Manifest

The Manifest of a Deployment Package consists of a *global section* and separate sections for each resource contained within it, called the *Name sections*. The global section of a Deployment Package Manifest can contain the following headers that have a defined meaning in this specification:

- DeploymentPackage-SymbolicName – The name of the deployment package as a reverse domain name. For example, com.acme.chess. See further *DeploymentPackage-SymbolicName* on page 214.
- DeploymentPackage-Version – The version of the deployment package as defined in [2] *OSGi Service Platform Core Specification*. See further *DeploymentPackage-Version* on page 214.
- DeploymentPackage-FixPack – Marks this deployment package as a partial update to a resident deployment package. See *Fix Package* on page 217.

The following headers provide information about the Deployment Package, but are not interpreted by the Deployment Admin service.

- *DeploymentPackage-Copyright* – Specifies the copyright statement for this Deployment Package.
- *DeploymentPackage-ContactAddress* – How to contact the vendor/ developer of this Deployment Package.
- *DeploymentPackage-Description* – A short description of this Deployment Package.
- *DeploymentPackage-DocURL* – A URL to any documentation that is available for this Deployment Package. The URL can be relative to the JAR file.
- *DeploymentPackage-Vendor* – The vendor of the Deployment Package.

- *DeploymentPackage-License* – A URL to a license file. The URL can be relative to the Deployment Package JAR file.

As with any JAR file Manifest, additional headers can be added and must be ignored by the Deployment Admin service. If any fields have human readable content, localization can be provided through property files as described in *Localization* on page 62 in [2] *OSGi Service Platform Core Specification*. The Deployment Admin service must always use the raw, untranslated version of the header values.

For example, the global section of a Deployment Package Manifest could look like:

```
Manifest-Version: 1.0
DeploymentPackage-SymbolicName: com.third._3d
DeploymentPacakge-Version: 1.2.3.build22032005
DeploymentPackage-Copyright: ACME Inc. (c) 2003
↵
```

Additionally, the Deployment Package Manifest must carry a *Name section* for each resource in the JAR file (except the resources in the META-INF directory). Each name section must start with an empty line (carriage return and line feed, shown as ↵ when its usage could be ambiguous).

The Name section must start with a Name header that contains the path name of the resource. This path name is also used as resource id. The path name must be constructed with the characters as defined in *Path Names* on page 212. For example:

```
Name: bundles/3dlib.jar
```

The name section can include any additional relevant meta data for the named resource. For bundles, only the specification of the Bundle-SymbolicName and Bundle-Version headers are required, but other headers can be added. Unrecognized headers are allowed and must be ignored by the Deployment Admin service. The Name section is also used by the JAR signing to include digests of the actual resources.

The following headers are architected for the Name section in the manifest of a deployment package:

- *Bundle-SymbolicName* – Only for bundle resources. This header must be identical to the Bundle Symbolic Name of the named bundle. If there is a discrepancy, the install of the Deployment Package must fail. If the bundle resource has no Bundle-SymbolicName in its manifest, however, the Deployment Admin must use the given symbolic name for the calculation of the location of this bundle.
- *Bundle-Version* – Only for bundle resources. This header must be identical to the bundle version of the named bundle. Its syntax must follow the version syntax as defined in the Framework specification. The installation must fail if incorrect.
- *DeploymentPackage-Missing* – (true|false) Indicates that the resource is logically part of the Deployment Package but that a previous version of the Deployment Package already contained this resource—there is no data for this resource. See *Fix Package* on page 217 for a further explanation.

- *Resource-Processor* – The PID of the Resource Processor service that must install the given resource.
- *DeploymentPackage-Customizer* – (true|false) Indicates whether this bundle is a customizer bundle by listing a PID for the customizer service. See a further discussion in *Customizer* on page 218.

An example Manifest of a Deployment Package that deploys the 3D package, consisting of two bundles and no resources, could look like:

```
Manifest-Version: 1.0
DeploymentPackage-SymbolicName: com.third._3d
DeploymentPacakge-Version: 1.2.3.build22032005
↵
Name: bundles/3dlib.jar
SHA1-Digest: MOez1l4gXHBo8ycYdAxstK3UvEg=
Bundle-SymbolicName: com.third._3d
Bundle-Version: 2.3.1
↵
Name: bundles/3dnative.jar
SHA1-Digest: N8Ow2UY4yjnHZv5zeq2I1Uv/+uE=
Bundle-SymbolicName: com.third._3d.native
Bundle-Version: 1.5.3
↵
Name: OSGI-INF/autoconf.xml
SHA1-Digest: M78w24912HgiZv5zeq2X1Uv-+uF=
Resource-Processor:
  org.osgi.deployment.rp.autoconf
↵
```

114.3.4 Deployment Package Headers

This section contains a detailed description of the different headers for a Deployment Package with their value syntax.

114.3.4.1 DeploymentPackage-SymbolicName

The name of the deployment package. A name must follow the same rules as Java packages. The grammar is as follows:

```
DeploymentPackage-SymbolicName ::= unique-name
                                   // See 1.4.2 Core
```

This header is mandatory and must not be localized.

An example is:

```
DeploymentPackage-SymbolicName: com.acme.chess
```

114.3.4.2 DeploymentPackage-Version

This header defines the version of the deployment package. The syntax follows the standard OSGi Framework rules for versions.

```
DeploymentPackage-Version ::= version    // See 3.2.4 Core
```

This header is mandatory and must follow the syntax of the version. It must not be localized.

An example:

```
DeploymentPackage-Version: 1.2.3.build200501041230
```

114.3.4.3 DeploymentPackage-FixPack

A fix package can be distinguished from the full format Deployment Package through the presence of the DeploymentPackage-FixPack header, contained within the global section of the Manifest. The format of this header is:

```
DeploymentPackage-FixPack ::= version-range
                                // See 3.2.5 Core
```

The version range syntax is identical to the Framework module's layer version range as defined in [2] *OSGi Service Platform Core Specification*. For example, a Manifest header that denotes a fix package which is only applicable to versions 1.3 through 3.4 of a given deployment package looks like:

```
DeploymentPackage-FixPack: [1.3,3.4]
```

See *Fix Package* on page 217 for more information about Fix Packages.

114.3.4.4 Bundle-SymbolicName (Name Section)

The Bundle-SymbolicName header must be a copy of the Bundle-SymbolicName header in the named bundle, including any parameters. This header must match the Bundle-SymbolicName of the actual bundle; if it does not, the install or update must fail. The parameters, however, can differ between updates. The header has the following format:

```
Bundle-SymbolicName: unique-name (';' parameter ) *
```

If the bundle resource has no Bundle-SymbolicName header, the given symbolic name must be used to calculate the location of the bundle.

For example:

```
Name: bundles/http.jar
Bundle-SymbolicName: com.acme.http; singleton=true
```

114.3.4.5 Bundle-Version (Name Section)

The Bundle-Version header must be equal to the Bundle-Version header in the named bundle. It must follow the format as defined for the version clause in [2] *OSGi Service Platform Core Specification*.

```
Bundle-Version ::= version      // See 3.2.4 Core
```

A mismatch between the version indicated in the Manifest of the Deployment Package and the actual value in the Bundle's Manifest must cause an installation or update to fail.

For example

```
Bundle-Version: 1.2
```

114.3.4.6 Resource-Processor (Name Section)

The Resource-Processor header selects an OSGi Resource Processor service for this resource by selecting the Resource-Processor service with the given PID as service.id service property. This header is optional, so that the Deployment Package can carry resources that are not processed: for example, license and documentation files. The format of the header is:

```
Resource-Processor ::= pid      // See 1.4.2 Core
```

For example:

```
Name: certificate/certificates.xml
SHA1-Digest: M78w249126182Ak5zeq2X1Uv-+uF=
Resource-Processor: com.securitas.keystore
```

In the example, the certificates.xml in the certificate directory will be processed by the Resource Processor service registered with the service property service.pid set to com.securitas.keystore. The service.pid is a standard Framework property to uniquely identify a service instance called a Persistent IDentity a.k.a. PID.

114.3.4.7 DeploymentPackage-Missing (Name Section)

Fix packs (see *Fix Package* on page 217) are Deployment Packages that do not contain all the resources for a full install. This header indicates the Bundle Symbolic Name of a bundle that is not present in the enclosing JAR file but should be part of a prior version of this Deployment Package. The format is:

```
DeploymentPackage-Missing ::= 'true' | 'false'
```

The default value for this header is false. An error results if this header is true and the resource is not present in the existing Deployment Package.

For example:

```
Name: bundles/3dlib.jar
DeploymentPackage-Missing: true
Bundle-SymbolicName: com.acme.http
Bundle-Version: 3.0
```

114.3.4.8 DeploymentPackage-Customizer (Name Section)

This header is used to indicated that a resource is a customizer bundle, as described in *Customizer* on page 218. The syntax of this optional header is:

```
DeploymentPackage-Customizer ::= 'true' | 'false'
```

The default for this header is false.

For example:

```
Name: bundles/3dlibcustomizer.jar
DeploymentPackage-Customizer: true
Bundle-SymbolicName: com.acme.customizer
Bundle-Version: 3.6
```

114.3.5 Localization

All human readable headers can be localized using the same mechanism as is used to localize the manifest of a bundle. This mechanism is described in *Localization* on page 62 of the [2] *OSGi Service Platform Core Specification.*

For example, a Manifest could look like:

```
Manifest-Version: 1.0
DeploymentPackage-ManifestVersion: 1
DeploymentPackage-SymbolicName: com.third._3d
DeploymentPacakge-Version: 1.2.3.build22032005
DeploymentPackage-Copyright: %copyright
DeploymentPackage-Vendor: %vendor
```

```
DeploymentPackage-License: %licenseurl
DeploymentPackage-Description: %3dlib
Bundle-Localization: OSGI-INF/l10n/dp
↵
Name: bundles/3dlib.jar
SHA1-Digest: MOez1l4gXHBo8ycYdAxstK3UvEg=
Bundle-SymbolicName: com.third._3d
Bundle-Version: 2.3.1
↵
Name: OSGI-INF/autoconf.xml
SHA1-Digest: M78w24912HgiZv5zeq2X1Uv-+uF=
Resource-Processor:
  org.osgi.deployment.rp.autoconf
↵
```

Different language translations can be provided, such as:

```
OSGI-INF/l10n/dp.properties:
copyright=ACME Inc. (c) 2005
vendor=ACME Inc.
license=OSGI-INF/license.en.txt
3dlib=High performance graphic library

OSGI-INF/l10n/dp_nl.properties:
copyright=ACME Holland BV (c) 2005
vendor=ACME Holland BV.
license=OSGI-INF/licentie.txt
3dlib=Zeer snelle 3D grafische routine bibliotheek
```

The language translation resources should appear in the Name section of the manifest so they can be signed.

114.4 Fix Package

A Fix Package is a Deployment Package that minimizes download time by excluding resources that are not required to upgrade or downgrade a Deployment Package. It can only be installed on a Service Platform if a previous version of that Deployment Package is already installed. The Fix Package contains only the changed and new resources. A Fix Package (called the *source*) therefore must specify the range of versions that the existing Deployment Package (called the *target*) must have installed. This range is specified with the `DeploymentPackage-FixPack` header in the manifest of the source.

The Manifest format for a Fix Package is, except for the Fix Package header, the same as for a Deployment Package manifest: each resource must be named in the Name section of the Manifest. Resources that are absent, however, must be marked in the named section with the DeploymentPackage-Missing header set to `true`.

Thus, the name sections of the manifest of a Fix Package must list *all* resources, absent or present, in order to distinguish between resources that must be removed or resources that are absent. Name sections that specify the DeploymentPackage-Missing header, however, indicate that the actual content of the resource is not carried in the Deployment Package—that is, the resource content is absent. Only a Fix Package is permitted to contain the DeploymentPackage-Missing headers.

For example, the following headers define a valid Fix Package that can update an existing Deployment Package, only if the version is between 1 and 2.

```
Manifest-Version: 1.0
DeploymentPackage-SymbolicName: com.acme.package.chess
DeploymentPackage-Version: 2.1
DeploymentPackage-FixPack: [1,2)
↵
Name: chess.jar
Bundle-SymbolicName: com.acme.bundle.chess
DeploymentPackage-Missing: true
Bundle-Version: 5.7
↵
Name: score.jar
Bundle-SymbolicName: com.acme.bundle.chessscore
Bundle-Version: 5.7
↵
```

In this example, the Fix Package requires that version 1.x.y of the deployment package is already installed. The presence of the com.acme.bundle.chess bundle on the Service Platform is assumed, and it must be part of the existing Deployment Package com.acme.package.chess. After installation, this Deployment Package must contain the two listed bundles.

114.5 Customizer

The standardized Deployment Admin service installation and uninstallation functions do not always cover the needs of a developer. In certain cases, running custom code at install and uninstall time is required. This need is supported with the Deployment Package *Customizer*. Typical Customizer bundles are:

- Database initialization
- Data conversion
- Wiring

A Customizer bundle is indicated by a DeploymentPackage-Customizer header in a Name section for a bundle resource. A Deployment Package can a number of customizers, or none. A Customizer bundle must be installed and started by the Deployment Admin service *before* any of the resources are processed.

As a Customizer bundle is started, it should register one or more Resource Processor services. These Resource Processor services must only be used by resources originating from the same Deployment Package. Customizer bundles must never process a resource from another Deployment Package, which must be ensured by the Deployment Admin service.

Customizers are installed and started in the order that they appear in the Deployment Package.

114.5.1 Bundle's Data File Area

Each bundle in the OSGi Framework has its own persistent private storage area. This private area is accessed by a bundle with the getDataFile method on the Bundle Context. The location in the file system where these files are stored is not defined, and thus is implementation-dependent. A Customizer bundle, however, typically needs access to this private storage area.

The Deployment Admin service provides access to the Bundle private storage area with the getDataFile(Bundle) method on the DeploymentSession object. This method returns a File object to the root of the data directory.

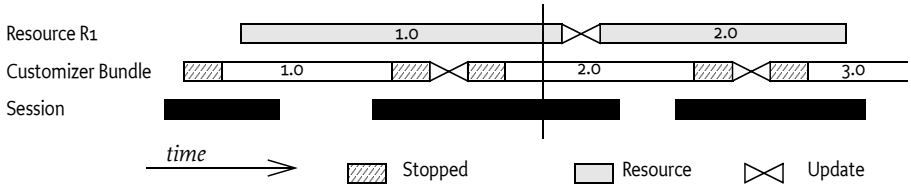
The location of a bundle's private storage area is impossible to determine because it depends on the implementation of the OSGi Framework. It is therefore impossible to give a Customizer bundle an appropriate File Permission for customization of a bundle's data area.

Therefore, if a Customizer bundle calls the getDataFile method for a specific bundle, the Deployment Admin must add to the Customizer bundle the required File Permission to access this area. This File Permission must be removed after the session ends.

114.5.2 Customizers and Update

The lifecycle of a customizer bundle is intertwined with the lifecycle of the resources it processes. Care should be taken to ensure that updates and uninstallations are handled correctly. A Customizer bundle is updated *before* a resource is processed—implying that a deployment session n is always dropped or processed by the customizer from session n+1. In this case, a session is an install or uninstall of a Deployment or Fix Package.

Figure 114.6 Time line for customizer versus resource versions



In Figure 114.6, Customizer bundle 2.0 must update the resource from version 1.0, and customizer 3.0 must drop the resource from version 2.0. As a consequence, the Customizer bundle that processes a resource will be a different version than the one that processes or drops it.

The same ordering issue is also relevant with respect to the Autoconf resources (see *Auto Configuration Specification* on page 261). Autoconf resources will not be available until the commit method is called. This condition implies that a customizer cannot receive fresh configuration information from the Deployment Package.

114.6 Deployment Admin Service

The Deployment Admin service provides the following services:

- *Introspecting* – Provide information about the Deployment Package repository. Introspecting is further discussed on *Introspection* on page 220.
- *Install* – The installation of a Deployment Package is described in *Installing a Deployment Package* on page 224.
- *Uninstall* – The uninstallation of a Deployment Package is described in *Uninstalling a Deployment Package* on page 230.
- *Canceling* – An ongoing session can be canceled with the cancel method described in *Canceling* on page 221.

An important concept of the Deployment Admin service is the *session*. Installations and uninstallations of Deployment Packages take place inside a session. This session is represented by a DeploymentAdminSession object. The session provides access to the Deployment Package that is being (un)installed, as well as access to the data area of bundles. The transactional aspects of this sessions are discussed in *Sessions* on page 221.

114.6.1 Introspection

The Deployment Admin service can provide the list of currently installed Deployment Packages with the listDeploymentPackages() method. Given a name, it is also possible to get a Deployment Package with getDeploymentPackage(String) using the name, or getDeploymentPackage(Bundle) for the Deployment Package of a specific bundle.

The listDeploymentPackages() method returns an array of DeploymentPackage objects. This list of Deployment Packages must contain only valid installed packages. During an installation or upgrade of an existing package, the target must remain in this list until the installation process is complete, after which the source replaces the target. If the installation fails, the source must never become visible, even transiently.

DeploymentPackage objects provide access to the following identity information:

- getName() – The name of the Deployment Package.
- getVersion() – The version of the Deployment Package.

The Deployment Package also provides access to the bundles that are associated with a Deployment Package.

- getBundleInfos() – Returns an array of information about all bundles that are *owned* by this Deployment Package. The return type is a BundleInfo object that has a getVersion() and getSymbolicName() method.
- getBundle(String) – Returns the bundle with the given Bundle Symbolic Name that is associated with this Deployment Package. As this instance

is transient—for example, a bundle can be removed at any time because of the dynamic nature of the OSGi platform—this method may also return null, if the bundle is part of this deployment package but is temporarily not defined in the Framework.

The Deployment Package also provides access to the headers in its Manifest. The global section and the Name sections are both supported. This information can be used to provide human-readable information to the end user. If the Manifest is using localization, this information must be returned in the default locale. It is not possible to specify a specific locale. See *Localization* on page 216 for more information.

- getHeader(String) – Provides access to the Deployment Package's Manifest header global section. Header names must be matched in a case-insensitive manner.
- getResourceHeader(String,String) – Provides access to a header in the Name section. The first argument specifies the resource id (JAR path); the second argument is the (case insensitive) header name.

The Deployment Package contains a number of resources. Each resource can be queried for its associated Resource Processor service.

- getResourceProcessor(String) – Return the Service Reference of the Resource Processor service that is associated with the given resource. For a Bundle resource, the returned Resource Processor must be null.
- getResources() – Return an array of resource names. This array must include the Bundle resources.

The isStale() method returns true when DeploymentPackage object is no longer available.

114.6.2 Canceling

An ongoing session can be canceled with the Deployment Admin service's cancel() method. This method must find the currently executing Resource Processor service and call its cancel method. The remainder of the session must be immediately rolled back after the Resource Processor returns from the active method.

114.7 Sessions

The (un)installation or upgrade of a deployment package requires the cooperation and interaction of a large number of services. This operation, therefore, takes place in a *session*. A session must be created by the Deployment Admin service before any activity on behalf of the Deployment Package takes place, including any bundle installations. Sessions are not visible to the clients of Deployment Admin service.

Before using a resource processor in a session, the Deployment Admin service must *join* the Resource Processor service to the session. The begin(DeploymentSession) method must be called before a Resource Processor service calls the process, drop, or dropAllResources method. For brevity, this joining is not shown in the following sections, but must be assumed to have taken place before any of the methods is called.

A Resource Processor has *joined the session* when it has returned from its begin(DeploymentSession) method without an Exception being thrown. A Resource Processor service must not be joined to more than a single session at any moment in time—implying that a Resource Processor can assume that only one install takes place at a time.

A roll back can take place at any moment during a session. It can be caused by a Resource Processor service that throws an Exception during a method call, or it can be caused by canceling the session (see *Canceling* on page 221).

If all methods in a session are executed without throwing Exceptions, then the session must be committed. Commitment first requires a vote about the outcome of the session in the so-called *prepare* phase. The Deployment Admin service must therefore call the prepare method on all Resource Processor services that have joined the session. The Resource Processor services must be called in the reverse order of joining.

Any Resource Processor that wants to roll back the session in the prepare phase can, at that moment, still throw an Exception. The prepare method can also be used to persist some of the changes, although the possibility remains that the session will be rolled back and that those changes must then be undone.

If all joined Resource Processors have successfully executed the prepare method, the Deployment Admin service must call the commit method on all Resource Processor services that have joined the session. The Resource Processor services must be called in the reverse order of joining. Resource Processor services must not throw an Exception in this method; they should only finalize the commit. Any Exceptions thrown should be logged, but must be ignored by the Deployment Admin service.

114.7.1 Roll Back

At the moment of the roll back, a number of Resource Processor services can have joined the session and bundles could have been installed. For each of these joined Resource Processor services, the Deployment Admin service must call the rollback() method. A roll back can be caused by a thrown Exception during an operation, or can be initiated by the caller. The roll back can even happen after the prepare() method has been called if another Resource Processor throws an Exception in its prepare method. The Resource Processor services must be called in the reverse order of joining for the rollback method.

The system should make every attempt to roll back the situation to its pre-session state:

- Changed artifacts must be restored to their prior state
- New artifacts must be removed
- Stale artifacts must be created again
- Any installed or updated bundles must be removed
- The state of the target bundles must be restored

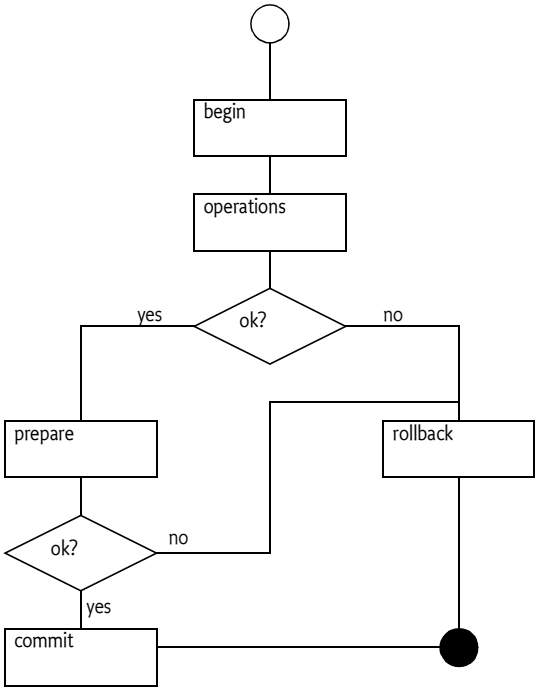
If the target bundles were started before, and the state can be restored successfully, the target bundles must be refreshed (the PackageAdmin refreshPackages method) and started again before the method returns.

If the roll back cannot completely restore the state of the target bundles, the target bundles that were restored must not be restarted, in order to prevent running bundles with incompatible versions. An appropriate warning should be logged in this case.

After the commit or rollback method, the DeploymentAdminSession object is no longer usable.

The transactional aspects of the session are depicted in Figure 114.7.

Figure 114.7 Transactional Sessions



The Deployment Admin service must uninstall any new bundles and install *stale* bundles (bundles that were uninstalled during the session), and should roll back updated bundles. Rolling back a bundle update, as well as reinstalling a stale bundle, requires an implementation-dependent back door into the OSGi Framework, because the Framework specification is not transactional over multiple lifecycle operations. Therefore, this specification does not mandate full transactional behavior.

After a roll back, however, a Deployment Package must still be removable with all its resources and bundles dropped. A roll back must not bring the Deployment Package to a state where it can no longer be removed, or where resources become orphaned.

114.7.2 Bundle Events During Deployment

Deployment operations usually result in bundles being installed or uninstalled. These deployment operations can fail in mid-operation, and cause a roll back by Deployment Admin—meaning that the platform can go through some transient states in which bundles are installed, then uninstalled due to roll back.

Therefore, the order of Bundle events produced by a transactional implementation must be compatible with the Bundle events produced by a non-transactional implementation. A transactional implementation, however, can choose to postpone all events while maintaining ordering until the end of the session and thereby canceling any events that cancel each other (e.g. install and uninstall). A non-transactional Deployment Admin service must send out the events as they occur.

In the following example, a simple Deployment Package consists of bundles A, B, and C. If this Deployment Package is successfully installed, an implementation must produce the following Bundle events (in order):

1 BundleEvent(INSTALLED) for bundle A
2 BundleEvent(INSTALLED) for bundle B
3 BundleEvent(INSTALLED) for bundle C

If an operation of this Deployment Package was unsuccessful because, for example, Bundle C could not be installed due to an error, then the Deployment Admin service must roll back the deployment operation to return the platform to its original state. If the Deployment Admin service is transactional, then it must not expose the events because no persistent bundle changes were made to the platform.

On the other hand, a non-transactional implementation must expose the transient bundle states that occur during the deployment operation. In this case, the following bundle events could have been generated (in order):

1 BundleEvent(INSTALLED) for bundle A
2 BundleEvent(INSTALLED) for bundle B
3 BundleEvent(UNINSTALLED) for bundle A
4 BundleEvent(UNINSTALLED) for bundle B

114.8 Installing a Deployment Package

Installation starts with the installDeploymentPackage(InputStream). No separate function exists for an update; if the given Deployment Package already exists, it must be replaced with this new version. The purpose of the installDeploymentPackage method is to replace the *target* Deployment Package (existing) with the *source* Deployment Package (contained in the Input Stream).

The InputStream object must stream the bytes of a valid Deployment Package JAR; it is called the *source* deployment package. The InputStream object must be a general InputStream object and not an instance of the JarInputStream class, because these objects do not read the JAR file as bytes.

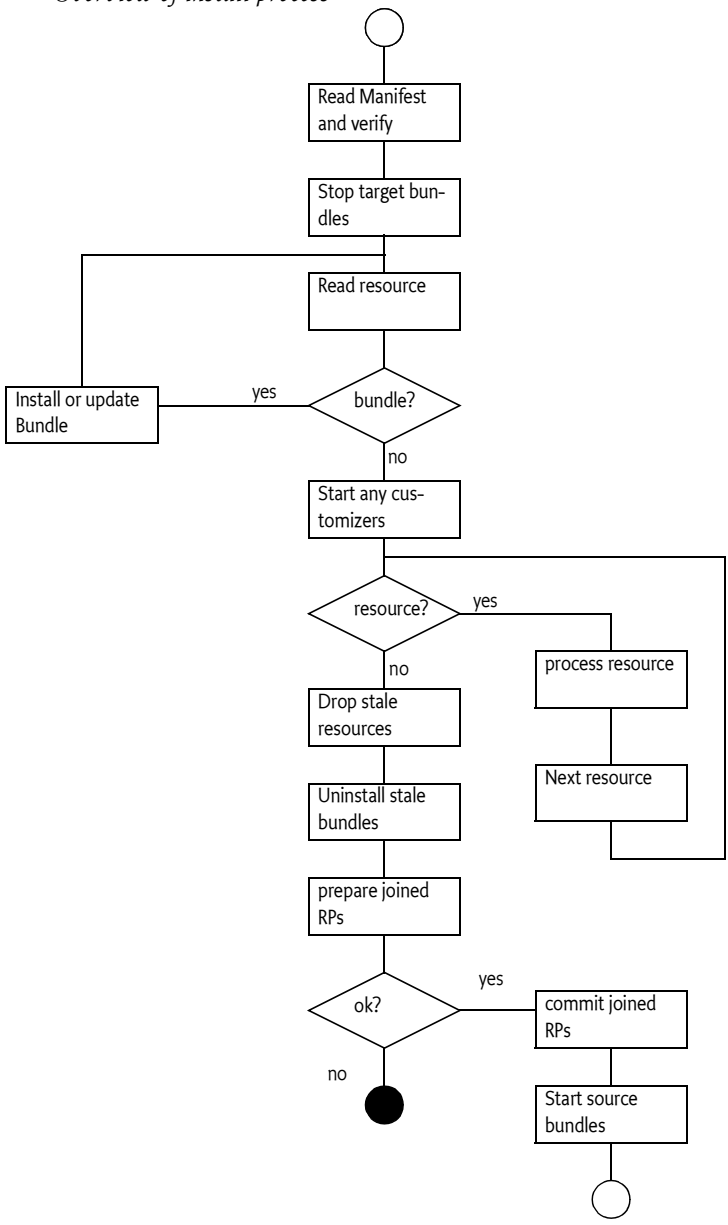
If an installed Deployment Package has the same name as the source, it is called the *target* Deployment Package. If no target exists, an invisible empty target with a version of 0.0.0. must be assumed without any bundles and resources.

The installation of a deployment package can result in these qualifications for any resource r:

- $r \in source, r \notin target$ – New resource
- $r \notin source, r \in target$ – Stale resource
- $r \in source, r \in target$ – Updated resource

The short scenario for an install is depicted in Figure 114.8.

Figure 114.8 Overview of install process



In more detail, to install a Deployment Package, a Deployment Admin service must:

1 Create a Deployment Session
2 Assert that the Manifest file is the first resource in the Deployment Package JAR file.
3 Assert the following:

- The source must not contain any bundle that exists in other deployment packages, except for the target. The source bundles, as defined by the symbolic name, must belong to the target or be absent.

If the source is a Fix Package, assert that:

- The version of the target matches the required source version range.
- All the missing source bundles are present in the target.

Otherwise:

- Assert that are no missing resources or bundles declared.

4 All target bundles must be stopped in reverse target resource order. Exceptions thrown during stopping must be ignored, but should be logged as warnings.

The target is now stopped; none of its bundles are running any longer. The next step requires the sequential processing of the resources from the source JAR file in source resource order. The bundles must be processed first (if present), and can be followed by any number of resources, or none.

For each bundle read from the source JAR stream:

5 If the bundle symbolic name already exists in the system with a different version number, update that bundle with the resource stream. If the version is identical, the resource stream must be ignored. The `update` method must follow the semantics of the OSGi Framework `update` method. An exception thrown during the update must roll back the session.
Otherwise, install the bundle according to the semantics of the OSGi Framework `installBundle` method. The location of the bundle must be set to the Bundle Symbolic Name without any parameters and be prefixed with the `osgi-dp:` scheme. An exception thrown during the install must roll back the session.
Framework events are discussed in *Bundle Events During Deployment* on page 224.

6 Assert that the installed bundle has the Bundle Symbolic Name and version as defined by the source manifest. If not, the session must be rolled back.

All the source's bundles are now installed or updated successfully. Next, any customizers must be started so that they can participate in the resource processing:

7 If Customizer bundles or stale customizers are defined, start them. If any Customizer bundle's start method throws an exception, the session must be rolled back.

For each resource read from the JAR stream:

8 Find the Resource Processor service that processes the resource by using the PID in the Resource-Processor header. If it cannot be found, the session must be rolled back.

9 Assert that the matched Resource Processor service is not from a Customizer bundle in another Deployment Package.

10 Call the matched Resource Processor service process(String,InputStream) method. The argument is the JAR path of the resource. Any Exceptions thrown during this method must abort the installation.

All resource updates and installs have now occurred. The next steps must remove any stale resources. First the stale resources are dropped, and then the bundles are uninstalled. Exceptions are ignored in this phase to allow repairs to always succeed, even if the existing package is corrupted.

11 In reverse target order, drop all the resources that are in the target but not in the source by calling the matching Resource Processor service dropped(String) method. Any exceptions thrown during this method should be logged as warnings, but must be ignored.
12 Uninstall all stale bundles in reverse target order, using the OSGi Framework uninstall method semantics. Any exceptions thrown should be logged as warnings, but must be ignored.

The deployment package is now cleaned up, and can be activated and committed.

13 All the Resource Processor services that have joined the session must now prepare to commit, which is achieved by calling the prepare() method. If any Resource Processor throws an Exception, the session must roll back. The Resource Processors must be called in the reverse order of joining.
14 If all the Resource Processors have successfully prepared their changes, then all the Resource Processor services that have joined the session must now be committed, which is achieved by calling the commit() method. The Resource Processors must be called in the reverse order of joining. Any exceptions should be logged as warnings, but must be ignored.
15 Call the Package Admin service refreshPackages method so that any new packages are resolved.
16 Wait until the refresh is finished.
17 Start the bundles in the source resource order. Exceptions thrown during the start must be logged, but must not abort the deployment operation.

The session is closed and the source replaces the target in the Deployment Admin service's repository.

The installDeploymentPackage method returns the source Deployment Package object.

114.8.1 Example Installation

The target Deployment Package has the following manifest:

```
Manifest-Version: 1.0 ↵
DeploymentPackage-SymbolicName: com.acme.daffy ↵
DeploymentPackage-Version: 1 ↵
↵
Name: bundle-1.jar
Bundle-SymbolicName: com.acme.1
Bundle-Version: 5.7↵
↵
Name: r0.x↵
Resource-Processor: RP-x↵
↵
Name: r1.x↵
Resource-Processor: RP-x ↵
```

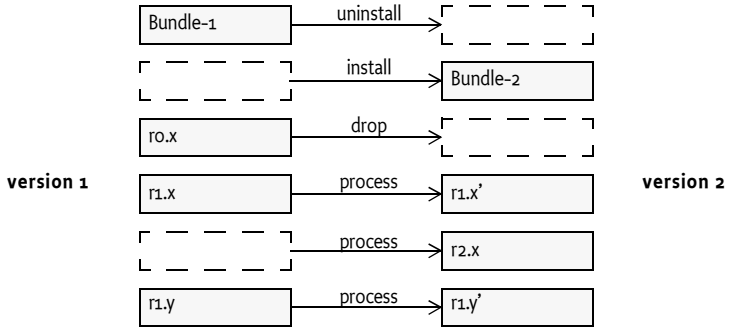
```
↵
Name: r1.y↵
Resource-Processor: RP-y↵
↵
```

This deployment package is updated with a new version, with the following manifest:

```
Manifest-Version: 1.0
DeploymentPackage-SymbolicName: com.acme.daffy
DeploymentPackage-Version: 2
↵
Name: bundle-2.jar
Bundle-SymbolicName: com.acme.2
Bundle-Version: 5.7↵
↵
Name: r1.x↵
Resource-Processor: RP-x↵
↵
Name: r2.x↵
Resource-Processor: RP-x↵
↵
Name: r1.y↵
Resource-Processor: RP-y↵
↵
```

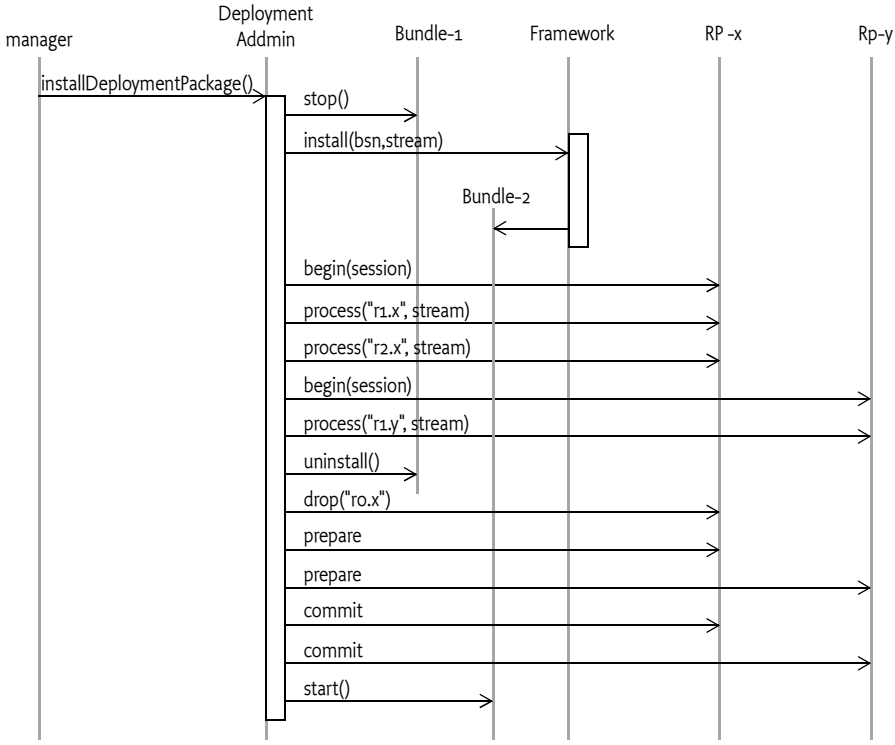
The delta between version 1 and version 2 of the com.acme.daffy Deployment Package is depicted in Figure 114.9. Bundle-1 must be uninstalled because it is no longer present in the Deployment Package com.acme.daffy version 2. Bundle-2 is a new bundle and thus must be installed. The resource r0.x must be dropped and r1.x must be updated (this must be detected and treated accordingly by Resource Processor RP-x). r2.x is a new resource. The resource r1.y is updated by Resource Processor RP-y).

Figure 114.9 Delta



The sequence diagram for the installation is shown in Figure 114.10.

Figure 114.10 Sequence Diagram for a Resource Processor



114.9 Uninstalling a Deployment Package

Uninstalling a Deployment Package must remove all the effects of its installation(s). The uninstall is started by calling uninstall() or uninstallForced() method on a *target* DeploymentPackage object.

The Deployment Packages are uninstalled explicitly, which may break the overall runtime configuration. No attempt is made to ensure that the uninstalled Deployment Package is required as a provider of Java packages or services, or fulfills other dependencies.

The Deployment Admin service must take the following actions to remove the target Deployment Package when uninstall() is called. This procedure must run inside a Deployment Admin session. A Resource Processor that is called must first join the session as described in *Sessions* on page 221.

Uninstalling is composed of the following steps:

1 Start a new Deployment Admin session.
2 Stop all the bundles owned by the Deployment Package. If this step throws a Bundle Exception, this error should be logged but must be ignored.
3 Call the dropAllResources() method on all the Resource Processor services that are owned by this Deployment Package. Absent Resource Pro-

cessor services or Exceptions that are thrown must immediately roll back this session.
4 Call the prepare method on the Resource Processor services that joined the session. If any Resource Processor service throws an Exception, the session must be rolled back.
5 Call the commit method on the Resource Processors that joined the session.
6 Uninstall all owned bundles.

Uninstalling a Deployment Package can break the overall runtime configuration. No attempt is made to ensure that a Deployment Package being uninstalled is not necessary as a provider of Java packages or services, or fulfills other dependencies.

An error condition results if the Resource Processor services are no longer present when uninstalling or updating a deployment package. A request to carry out an uninstall operation on such a Deployment Package must be refused until the Resource Processor services are all available. A means must be provided, however, to handle permanent unavailability of these services.

To address this issue, the DeploymentPackage interface provides a method, uninstallForced(), which forces removal of the Deployment Package from the repository maintained by the Deployment Admin service. This method follows the same steps described earlier. Any errors, or the absence of Resource Processor services, should be logged but ignored; they must not cause a roll back.

If errors occur or Resource Processor services are absent, it is likely that the uninstallation will be incomplete, and that some residual artifacts will remain on the platform. Whether this residue is eventually cleaned up, and how, is left up to the implementation.

114.10 Resource Processors

The Resource Processor service interprets the byte stream of a resource. Typically, the stream is parsed and its information is stored as *artifacts*. Examples of resource processors are:

- *Configuration Management* – This processor is standardized by the OSGi and more information can be found in *Auto Configuration Specification* on page 261.
- *Certificate Keystore* – A Certificate Keystore processor could extract certificates from a bundle and install them in a keystore.
- *SyncML Script* – Execute a series of SyncML commands.

The Deployment Admin service maintains the list of *resource ids* (the path name in the JAR) that are contained in a Deployment Package. Each resource is uniquely identified within a Deployment Package by its path name—hence the term "resource id." The Deployment Package's getResources() method provides a list of the resources ids.

The Resource Processor service is responsible for actually creating and deleting the resource related artifacts. The Resource Processor service must be able to remove the artifacts related to a resource that is being dropped using only the resource id.

The ResourceProcessor interface is based on a session (see *Sessions* on page 221). The transactionality is limited to the bracketing of any processing or dropping of resources.The bracketing begins when a Resource Processor joins an install session. A Resource Processor service can assume that it is never in two sessions at the same time (see *Threading* on page 237). It can, however, be called multiple times during the session to process different resources.

Before the Resource Processor service is used in an install or uninstall session, the Deployment Admin service must call the begin(DeploymentSession) method; this action makes the Resource Processor service join the session. This method must be used by the Resource Processor service to mark any changes for potential roll back, from this time until the prepare()/commit() or rollback() method is called.

When the session is opened, the Deployment Admin service can call the following methods on the Resource Processor service:

- process(String,InputStream) – The Resource processor must parse the Input Stream and persistently associate the resulting artifacts with the given resource id. It must be possible to remove those artifacts in a future time, potentially after a complete system restart. Keep in mind that a resource can be processed many times. A Deployment Package that updates to a newer version is likely to contain the same resources again. Care should be taken to ensure that these updates are real updates and do not add new, unwanted artifacts.
- dropped(String) – The artifacts that were associated with the given resource id must be removed. If the named resource does not exist, a warning should be logged but no Exception should be thrown.
- dropAllResources() – Remove all artifacts that are related to the current target Deployment Package. This method is called when a Deployment Package is uninstalled.
- cancel() – This method is called when the Resource Processor is in the process(String,InputStream), dropped(String) or dropAllResources() method, allowing the caller to cancel a long-running session. In that case, the Deployment Admin must call the cancel() method for the active Resource Processor service. The Resource Processor service should terminate its action as quickly as possible. The Resource Processor service must still handle a roll back of the session after it has returned.

All methods must perform any integrity checks immediately and throw an Exception with an appropriate code if the verification fails. These checks must not be delayed until the prepare or commit method. As stated earlier, changes must be recorded, but it should be possible to roll back the changes when the rollback method is called.

Deployment Packages can be upgraded or downgraded. Resource Processor services must therefore be capable of processing resources that have a lower, equal, or higher version.

114.10.1 Example Resource Processor

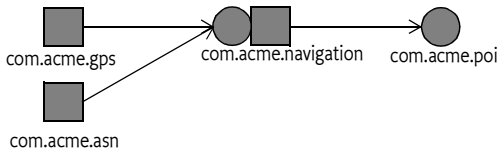
An example is a Resource Processor service that wires services with the Wire Admin service. The Wire Admin service creates wires between a *producer* and a *consumer* service, each identified by a PID. Wires are the artifacts that are installed and removed. Each wire contains a Dictionary object that is a convenient place to tag wires with the Deployment Package name and resource id. The Wire Admin stores this information persistently, which makes it very suitable for use in a transactional model. This small example supports full transactionality, although without crash recovery.

For simplicity, the wire definitions are stored in a format compatible with the java.util.Properties format (because it can simply be loaded from an Input Stream object). The key is the producer and the value is the consumer. A sample wiring could look like:

```
com.acme.gps = com.acme.navigation
com.acme.asn = com.acme.navigation
com.acme.navigation = com.acme.poi
```

This wiring is depicted in Figure 114.11.

Figure 114.11 Sample Wiring



This resource is stored in a Deployment Package JAR file. In this example there are no bundles, so the Deployment Package's manifest would look like:

```
Manifest-Version: 1.0
DeploymentPackage-SymbolicName: com.acme.model.E45.wiring
DeploymentPackage-Version: 1.2832
↵
Name: sample.wiring
Resource-Processor: wire.admin.processor
↵
```

To reduce the size of the code in this example, the Wire Admin service is received as a parameter. The constructor registers the object as a Resource Processor service with the required wire.admin.processor PID.

The transaction strategy of this code is to create wires when new wires have to be created, but to delay the deletion of wires until the end of the session. Any created wires are kept in the createdWires field, and the wires that are to be deleted are kept in the toBeDeletedWires field.

The current DeploymentPackage object is saved in the current field when the begin method is called.

```
public class WireAdminProcessor implements ResourceProcessor
{
   WireAdmin                admin;
```

```
DeploymentPackage       current;
List                    createdWires= new Vector();
List                    toBeDeletedWires= new Vector();

public WireAdminProcessor(
     WireAdmin admin, BundleContext context)
     throws Exception {
   this.admin = admin;
   Dictionary properties = new Hashtable();
   properties.put(Constants.SERVICE_PID,
        "wire.admin.processor");
      context.registerService(
         ResourceProcessor.class.getName(), this,
         properties);
}
```

When the Deployment Admin service is installing a Deployment Package JAR, it must call the Resource Processor service's begin method before the first time it calls a Resource Processor service to join it to the current session. In this case, only the source DeploymentPackage object is saved in the current field.

```
public void begin(DeploymentSession session) {
   current = session.getSourceDeploymentPackage();
}
```

The most complicated method that must be implemented is the process method. This method receives the resource id and an input stream with the contents. In this case, the stream is easily converted to a java.util.Properties object that contains the definitions of the wires.

The key and value of the Properties object are the producer and consumer respectively, which are used to create new wires. Each wire has a Dictionary object in the Wire Admin service. This Dictionary object is used to store the following properties:

- deployment.package – The symbolic name of the current (target) deployment package. This property associates the wire with a specific deployment package.
- resource.id – The resource id, or JAR path name. This id associates the specific resource with the wire.

Associating these fields with the wire simplifies finding all wires related to a Deployment Package or all wires related to a specific resource id and Deployment Package. The Wire Admin service supports a search method for wires that takes a filter as argument, further simplifying this process.

After a wire is created, it is stored in the createdWires list so that the wires can be deleted if the session is rolled back.

The process method looks as follows:

```
public void process(String resourceId, InputStream in)
        throws Exception {
   Properties properties = new Properties();
   properties.load(in);
   Dictionary dict = new Hashtable();
```

```
        dict.put("deployment.package", current.getName());
        for (Iterator i = properties.values().iterator();
             i.hasNext();) {
          dict.put("resource.id", resourceId );
          String producer = (String) i.next();
          String consumer = properties.getProperty(producer);
          Wire wire = admin.createWire(producer,
            consumer, dict);
          createdWires.add(wire);
        }
      }
```

If a resource is not in the source but is in the target Deployment Package, it must be dropped from the Resource Processor service. The Deployment Admin will call the dropped(String) method for those resources. Therefore, the wires that are tagged with the given resource id and Deployment Package name must be deleted.

The Wire Admin service has a convenient function to get all the wires that match a filter. This method is used to list all the wires that belong to the current Deployment Package as well as those that have the matching resource id. This array is added to the toBeDeletedWires field so that it can be deleted when the session is successfully completed—that is, wires are not deleted until the commit phase. When the session is rolled back, the list of wires to be deleted can be discarded, because they were never really deleted.

```
public void dropped(String name) throws Exception {
  List list = getWires(
    "(&(resource.id=" + name + ")(deployment.package="
      + current.getName() + "))");
  toBeDeletedWires.addAll(list);
}
```

If the session concludes without errors, the Deployment Admin service must call the prepare() method. In this example, it is possible to roll back the persistent changes made so far. The method can therefore just return.

```
public void prepare() {}
```

The commit() method must now actually delete the wires that were removed during the session. After these wires are deleted, the method can throw away the list of wires that were created. This list was only kept to remove the wires in case of a roll back.

```
public void commit() {
  delete(toBeDeletedWires);
  toBeDeletedWires.clear();
  createdWires.clear();
}
```

The rollback() method is the reverse of the commit. Any created wires must now be deleted to undo their creations in this session. The wires that are to be deleted can now be discarded, because they have not been deleted yet and therefore do not have to be rolled back.

```
public void rollback() {
  delete(createdWires);
```

```
        toBeDeletedWires.clear();
        createdWires.clear();
    }
```

The dropAllResources() method must drop all the wires that were created on behalf of the current Deployment Package. The filter on the getWires method makes this process very straightforward. Just delete all the wires that were tagged with the Deployment Package name.

```
public void dropAllResources() {
    List list = getWires("(deployment.package="
        + current.getName() + ")");
        toBeDeletedWires.addAll(list);
}
```

The cancel() method must cancel ongoing operations. This example does not have any long-running operations. The cancel method can therefore just return.

```
public void cancel() {}
```

And finally, some helper methods should be self-explanatory.

```
        void delete(List wires){
        while ( ! wires.isEmpty() )
            admin.deleteWire((Wire) wires.remove(0));
    }

    List getWires(String filter) {
        try {
            Wire[] wires = admin.getWires(filter);
            return Arrays.asList(wires);
        }
        catch (InvalidSyntaxException ise) {
            ise.printStackTrace();
        }
        return new Vector();
    }
}
```

This example is obviously not an "industrial-strength" implementation; its only purpose is to highlight the different problems that must be addressed. Implementors should therefore consider the following additional issues when implementing a Resource Processor service.

- Changes could have been made to the Deployment Package objects when a Resource Processor's bundle was updated or has been offline for some time, which can happen when the uninstallForceful method has been used. The Deployment Admin service can provide sufficient information to verify its repository to the information maintained in the Resource Processor service.
- A Resource Processor service should have a strategy for transactions that can handle crash recovery. For example, in the previous code the list of createdWires and toBeDeletedWires should have been logged. Logging these lists would have allowed full crash recovery.

- Better file formats should be considered. The Properties class is too restrictive because it can only have a single wire per Producer object. The Properties class was only chosen for its convenience.
- Multi-threading issues may exist with the cancel method.

114.11 Events

The Deployment Admin service must publish several generic events to the Event Admin service in the course of a deployment operation. The purpose of these events is to allow, for example, a user interface to display the progress of a deployment operation to the user.

The topics to which Deployment Admin publishes events are:

- org/osgi/service/deployment/INSTALL – The installDeployment-Package(InputStream) method has been called.
- org/osgi/service/deployment/UNINSTALL – The uninstall() or uninstallForced() method has been called..
- org/osgi/service/deployment/COMPLETE – The deployment operation has completed.

The INSTALL, UNINSTALL and COMPLETE events have the following property:

- *deploymentpackage.name* – (String) The name of the Deployment Package. This name is the same name as that specified in the DeploymentPackage-SymbolicName Manifest header.

The COMPLETE event additionally has the following property:

- *successful* – (Boolean) Whether the deployment operation was successful or not.

114.12 Threading

The Deployment Admin service must be a singleton and must only process a single session at a time. When a client requests a new session with an install or uninstall operation, it must block that call until the earlier session is completed. The Deployment Admin service must throw a Deployment Exception when the session cannot be created after an appropriate time-out period. Resource Processor services can thus assume that all calls from begin to commit or rollback methods are called from the same thread.

Special care should be taken with the cancel method that is usually called from another thread.

114.13 Security

114.13.1 Deployment Admin Permission

The Deployment Admin Permission is needed to access the methods of the Deployment Admin service. The target for a Deployment Admin Permission is the same Filter string as for an Admin Permission, see *Admin Permission* on page 95 of [2] *OSGi Service Platform Core Specification.*

The actions are:

- LIST – The permission to call the listDeploymentPackages() method and getDeploymentPackage(String).
- INSTALL – Allowed to call the installDeploymentPackage(InputStream) method.
- UNINSTALL – Allowed to call the uninstall() method.
- UNINSTALL_FORCED – Allowed to call the uninstallForced() method.
- CANCEL – Allowed to cancel an ongoing session.
- METADATA – Provide access to the Deployment Package meta data.

114.13.2 Deployment Customizer Permission

The DeploymentCustomizerPermission is used by customizer bundles. The target is the same as the target of Admin Permission: a filter that selects bundles. It has the following action:

- PRIVATEAREA – Permits the use of the private area of the target bundles.

114.13.3 Permissions During an Install Session

Unprotected, Resource Processor services can unwittingly disrupt the device by processing incorrect or malicious resources in a Deployment Package. In order to protect the device, Resource Processor service's capabilities must be limited by the permissions granted to the union of the permissions of the Deployment Package's *signers*. This union is called the *security scope*. Given a signer, its security scope can be obtained from the *Conditional Permission Admin Specification* on page 205.

The Deployment Admin service must execute all its operations, including calls for handling bundles and all calls that are forwarded to a Resource Processor service, inside a doPrivileged block. This privileged block must use an AccessControlContext object that limits the permissions to the security scope. Therefore, a Resource Processor service must assume that it is always running inside the correct security scope. A Resource Processor can, of course, use its own security scope by doing a local doPrivileged block.

114.13.4 Contained Bundle Permissions

Bundles can be signed independently from the vehicle that deployed them. As a consequence, a bundle can be granted more permissions than its parent Deployment Package.

114.13.5 Service Registry Security

114.13.5.1 Deployment Admin Service

The Deployment Admin service is likely to require All Permission. This requirement is caused by the plugin model. Any permission required by any of the Resource Processor services must be granted to the Deployment Admin service as well. This set is large and difficult to define. The following list, however, shows the minimum permissions required if the permissions for the Resource Processor service permissions are ignored.

```
ServicePermission    ..DeploymentAdmin          REGISTER
ServicePermission    ..ResourceProcessor        GET
PackagePermission    org.osgi.service.deploymentEXPORT
```

114.13.5.2 Resource Processor

```
ServicePermission    ..DeploymentAdmin          GET
ServicePermission    ..ResourceProcessor        REGISTER
PackagePermission    org.osgi.service.deploymentIMPORT
```

114.13.5.3 Client

```
ServicePermission    ..DeploymentAdmin          GET
PackagePermission    org.osgi.service.deploymentIMPORT
```

114.14 org.osgi.service.deploymentadmin

Deployment Admin Package 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.deploymentadmin; version=1.0
```

114.14.1 Summary

- BundleInfo - Represents a bundle in the array given back by the DeploymentPackage.getBundleInfos()[p.250] method. [p.239]
- DeploymentAdmin - This is the interface of the Deployment Admin service. [p.240]
- DeploymentAdminPermission - DeploymentAdminPermission controls access to the Deployment Admin service. [p.242]
- DeploymentException - Checked exception received when something fails during any deployment processes. [p.246]
- DeploymentPackage - The DeploymentPackage object represents a deployment package (already installed or being currently processed). [p.249]

114.14.2 public interface BundleInfo

Represents a bundle in the array given back by the DeploymentPackage.getBundleInfos()[p.250] method.

114.14.2.1 public String getSymbolicName( )

□ Returns the Bundle Symbolic Name of the represented bundle.

Returns the Bundle Symbolic Name

114.14.2.2 public Version getVersion( )

- Returns the version of the represented bundle.

Returns the version of the represented bundle

114.14.3 public interface DeploymentAdmin

This is the interface of the Deployment Admin service.

The OSGi Service Platform provides mechanisms to manage the life cycle of bundles, configuration objects, permission objects, etc. but the overall consistency of the runtime configuration is the responsibility of the management agent. In other words, the management agent decides to install, update, or uninstall bundles, create or delete configuration or permission objects, as well as manage other resource types, etc.

The Deployment Admin service standardizes the access to some of the responsibilities of the management agent. The service provides functionality to manage Deployment Packages (see DeploymentPackage[p.249]). A Deployment Package groups resources as a unit of management. A Deployment Package is something that can be installed, updated, and uninstalled as a unit.

The Deployment Admin functionality is exposed as a standard OSGi service with no mandatory service parameters.

114.14.3.1 public boolean cancel( )

- This method cancels the currently active deployment session. This method addresses the need to cancel the processing of excessively long running, or resource consuming install, update or uninstall operations.

Returns true if there was an active session and it was successfully cancelled.

Throws SecurityException – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] ("‹filter›", "cancel") permission.

See Also DeploymentAdminPermission[p.242]

114.14.3.2 public DeploymentPackage getDeploymentPackage(String symbName)

symbName the symbolic name of the Deployment Package to be retrieved. It mustn't be null.

- Gets the currenlty installed DeploymentPackage[p.249] instance which has the given symbolic name.

  During an installation of an existing package (update) or during an uninstallation, the target Deployment Package must remain the return value until the installation (uninstallation) process is completed, after which the source (or null in case of uninstall) is the return value.

Returns The DeploymentPackage for the given symbolic name. If there is no Deployment Package with that symbolic name currently installed, null is returned.

Throws IllegalArgumentException – if the given symbName is null

SecurityException – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] ("‹filter›", "list") permission.

See Also DeploymentPackage[p.249], DeploymentAdminPermission[p.242]

114.14.3.3 public DeploymentPackage getDeploymentPackage(Bundle bundle)

bundle the bundle whose owner is queried

- Gives back the installed DeploymentPackage[p.249] that owns the bundle. Deployment Packages own their bundles by their Bundle Symbolic Name. It means that if a bundle belongs to an installed Deployment Packages (and at most to one) the Deployment Admin assigns the bundle to its owner Deployment Package by the Symbolic Name of the bundle.

Returns the Deployment Package Object that owns the bundle or null if the bundle doesn't belong to any Deployment Packages (standalone bundles)

Throws IllegalArgumentException – if the given bundle is null

SecurityException – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] ("‹filter›", "list") permission.

See Also DeploymentPackage[p.249], DeploymentAdminPermission[p.242]

114.14.3.4 public DeploymentPackage installDeploymentPackage(InputStream in) throws DeploymentException

in the input stream the Deployment Package can be read from. It mustn't be null.

- Installs a Deployment Package from an input stream. If a version of that Deployment Package is already installed and the versions are different, the installed version is updated with this new version even if it is older (downgrade). If the two versions are the same, then this method simply returns with the old (target) Deployment Package without any action.

Returns A DeploymentPackage object representing the newly installed/updated Deployment Package. It is never null.

Throws IllegalArgumentException – if the got InputStream parameter is null

DeploymentException – if the installation was not successful. For detailed error code description see DeploymentException[p.246].

SecurityException – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] ("‹filter›", "install") permission.

See Also DeploymentAdminPermission[p.242], DeploymentPackage[p.249], DeploymentPackage[p.249]

114.14.3.5 public DeploymentPackage[] listDeploymentPackages( )

- Lists the Deployment Packages currently installed on the platform.

  DeploymentAdminPermission[p.242] ("‹filter›", "list") is needed for this operation to the effect that only those packages are listed in the array to which the caller has appropriate DeploymentAdminPermission. It has the consequence that the method never throws SecurityException only doesn't put certain Deployment Packages into the array.

  During an installation of an existing package (update) or during an uninstallation, the target must remain in this list until the installation (uninstallation) process is completed, after which the source (or null in case of uninstall) replaces the target.

Returns the array of DeploymentPackage objects representing all the installed Deployment Packages (including the "system" Deployment Package). The return value cannot be null. In case of missing permissions it may give back an empty array.

See Also `DeploymentPackage`[p.249] , `DeploymentAdminPermission`[p.242]

114.14.4 public final class DeploymentAdminPermission extends Permission

DeploymentAdminPermission controls access to the Deployment Admin service.

The permission uses a filter string formatted similarly to the org.osgi.framework.Filter. The filter determines the target of the permission. The DeploymentAdminPermission uses the name and the signer filter attributes only. The value of the signer attribute is matched against the signer chain (represented with its semicolon separated Distinguished Name chain) of the Deployment Package, and the value of the name attribute is matched against the value of the "DeploymentPackage-Name" manifest header of the Deployment Package. Example:

- (signer=cn = Bugs Bunny, o = ACME, c = US)
- (name=org.osgi.ExampleApp)

Wildcards also can be used:

```
(signer=cn=*,o=ACME,c=*)
```

"cn" and "c" may have an arbitrary value

```
(signer=*, o=ACME, c=US)
```

Only the value of "o" and "c" are significant

```
(signer=* ; ou=S & V, o=Tweety Inc., c=US)
```

The first element of the certificate chain is not important, only the second (the Distingushed Name of the root certificate)

```
(signer=- ; *, o=Tweety Inc., c=US)
```

The same as the previous but '-' represents zero or more certificates, whereas the asterisk only represents a single certificate

```
(name=*)
```

The name of the Deployment Package doesn't matter

```
(name=org.osgi.*)
```

The name has to begin with "org.osgi."

The following actions are allowed:

list

A holder of this permission can access the inventory information of the deployment packages selected by the ‹filter› string. The filter selects the deployment packages on which the holder of the permission can acquire detailed inventory information. See DeploymentAdmin.getDeploymentPackage(Bundle)[p.241], DeploymentAdmin.getDeploymentPackage(String)[p.240] and DeploymentAdmin.listDeploymentPackages[p.241].

install

A holder of this permission can install/update deployment packages if the deployment package satisfies the ‹filter› string. See DeploymentAdmin.installDeploymentPackage[p.241].

uninstall

A holder of this permission can uninstall deployment packages if the deployment package satisfies the ‹filter› string. See DeploymentPackage.uninstall[p.252].

uninstall_forced

A holder of this permission can forcefully uninstall deployment packages if the deployment package satisfies the ‹filter› string. See DeploymentPackage.uninstallForced[p.252].

cancel

A holder of this permission can cancel an active deployment action. This action being cancelled could correspond to the install, update or uninstall of a deployment package that satisfies the ‹filter› string. See DeploymentAdmin.cancel[p.240]

metadata

A holder of this permission is able to retrieve metadata information about a Deployment Package (e.g. is able to ask its manifest hedares). See org.osgi.service.deploymentadmin.DeploymentPackage.getBundle(String)[p.250], org.osgi.service.deploymentadmin.DeploymentPackage.getBundleInfos()[p.250], org.osgi.service.deploymentadmin.DeploymentPackage.getHeader(String)[p.250], org.osgi.service.deploymentadmin.DeploymentPackage.getResourceHeader(String, String)[p.251], org.osgi.service.deploymentadmin.DeploymentPackage.getResourceProcessor(String)[p.251], org.osgi.service.deploymentadmin.DeploymentPackage.getResources()[p.251]

The actions string is converted to lowercase before processing.

114.14.4.1 public static final String CANCEL = “cancel”

Constant String to the “cancel” action.

See Also DeploymentAdmin.cancel[p.240]

114.14.4.2 public static final String INSTALL = “install”

Constant String to the “install” action.

See Also DeploymentAdmin.installDeploymentPackage(InputStream)[p.241]

114.14.4.3 public static final String LIST = "list"

Constant String to the "list" action.

See Also DeploymentAdmin.listDeploymentPackages()[p.241], DeploymentAdmin.getDeploymentPackage(String)[p.240], DeploymentAdmin.getDeploymentPackage(Bundle)[p.241]

114.14.4.4 public static final String METADATA = "metadata"

Constant String to the "metadata" action.

See Also org.osgi.service.deploymentadmin.DeploymentPackage.getBundle(String)[p.250], org.osgi.service.deploymentadmin.DeploymentPackage.getBundleInfos()[p.250], org.osgi.service.deploymentadmin.DeploymentPackage.getHeader(String)[p.250], org.osgi.service.deploymentadmin.DeploymentPackage.getResourceHeader(String, String)[p.251], org.osgi.service.deploymentadmin.DeploymentPackage.getResourceProcessor(String)[p.251], org.osgi.service.deploymentadmin.DeploymentPackage.getResources()[p.251]

114.14.4.5 public static final String UNINSTALL = "uninstall"

Constant String to the "uninstall" action.

See Also DeploymentPackage.uninstall()[p.252]

114.14.4.6 public static final String UNINSTALL_FORCED = "uninstall_forced"

Constant String to the "uninstall_forced" action.

See Also DeploymentPackage.uninstallForced()[p.252]

114.14.4.7 public DeploymentAdminPermission(String name, String actions)

name filter string, must not be null.

actions action string, must not be null. "*" means all the possible actions.

□ Creates a new DeploymentAdminPermission object for the given name and action.

The name parameter identifies the target depolyment package the permission relates to. The actions parameter contains the comma separated list of allowed actions.

Throws IllegalArgumentException – if the filter is invalid, the list of actions contains unknown operations or one of the parameters is null

114.14.4.8 public boolean equals(Object obj)

obj The reference object with which to compare.

□ Checks two DeploymentAdminPermission objects for equality. Two permission objects are equal if:

- their target filters are semantically equal and

- their actions are the same

Returns true if the two objects are equal.

See Also `java.lang.Object.equals(java.lang.Object)`

114.14.4.9 public String getActions( )

□ Returns the String representation of the action list.

The method always gives back the actions in the following (alphabetical) order: cancel, install, list, metadata, uninstall, uninstall_forced

Returns Action list of this permission instance. This is a comma-separated list that reflects the action parameter of the constructor.

See Also `java.security.Permission.getActions()`

114.14.4.10 public int hashCode( )

□ Returns hash code for this permission object.

Returns Hash code for this permission object.

See Also `java.lang.Object.hashCode()`

114.14.4.11 public boolean implies(Permission permission)

permission Permission to check.

□ Checks if this DeploymentAdminPermission would imply the parameter permission.

Precondition of the implication is that the action set of this permission is the superset of the action set of the other permission. Further rules of implication are determined by the org.osgi.framework.Filter rules and the "OSGi Service Platform, Core Specification Release 4, Chapter Certificate Matching".

The allowed attributes are: name (the symbolic name of the deployment package) and signer (the signer of the deployment package). In both cases wildcards can be used.

Examples:

```
 1. DeploymentAdminPermission("(name=org.osgi.ExampleApp)",
"list")
 2. DeploymentAdminPermission("(name=org.osgi.ExampleApp)",
"list, install")
 3. DeploymentAdminPermission("(name=org.osgi.*)", "list")
 4. DeploymentAdminPermission("(signer=*, o=ACME, c=US)",
"list")
 5. DeploymentAdminPermission("(signer=cn = Bugs Bunny, o =
ACME, c = US)", "list")

 1. implies 1.
 2. implies 1.
 1. doesn't implies 2.
 3. implies 1.
 4. implies 5.
```

Returns true if this DeploymentAdminPermission object implies the specified permission.

See Also `java.security.Permission.implies(java.security.Permission)`, `org.osgi.framework.Filter`

114.14.4.12 public PermissionCollection newPermissionCollection( )

- Returns a new PermissionCollection object for storing DeploymentAdminPermission objects.

Returns The new PermissionCollection.

See Also `java.security.Permission.newPermissionCollection()`

114.14.5 public class DeploymentException extends Exception

Checked exception received when something fails during any deployment processes. A DeploymentException always contains an error code (one of the constants specified in this class), and may optionally contain the textual description of the error condition and a nested cause exception.

114.14.5.1 public static final int CODE_BAD_HEADER = 452

Syntax error in any manifest header.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.2 public static final int CODE_BUNDLE_NAME_ERROR = 457

Bundle symbolic name is not the same as defined by the deployment package manifest.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.3 public static final int CODE_BUNDLE_SHARING_VIOLATION = 460

Bundle with the same symbolic name alerady exists.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.4 public static final int CODE_CANCELLED = 401

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241], DeploymentPackage.uninstall()[p.252] and DeploymentPackage.uninstallForced()[p.252] methods can throw DeploymentException[p.246] with this error code if the DeploymentAdmin.cancel()[p.240] method is called from another thread.

114.14.5.5 public static final int CODE_COMMIT_ERROR = 462

Exception with this error code is thrown when one of the Resource Processors involved in the deployment session threw a ResourceProcessorException with the org.osgi.service.deploymentadmin.spi.ResourceProcessorException.CODE_PREPARE error code.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] and DeploymentPackage.uninstall()[p.252] methods throw exception with this error code.

114.14.5.6 public static final int CODE_FOREIGN_CUSTOMIZER = 458

Matched resource processor service is a customizer from another deployment package.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.7 public static final int CODE_MISSING_BUNDLE = 454

A bundle in the deployment package is marked as DeploymentPackage-Missing but there is no such bundle in the target deployment package.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.8 public static final int CODE_MISSING_FIXPACK_TARGET = 453

Fix pack version range doesn't fit to the version of the target deployment package or the target deployment package of the fix pack doesn't exist.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.9 public static final int CODE_MISSING_HEADER = 451

Missing mandatory manifest header.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] can throw exception with this error code.

114.14.5.10 public static final int CODE_MISSING_RESOURCE = 455

A resource in the source deployment package is marked as DeploymentPackage-Missing but there is no such resource in the target deployment package.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.11 public static final int CODE_NOT_A_JAR = 404

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] methods can throw DeploymentException[p.246] with this error code if the got InputStream is not a jar.

114.14.5.12 public static final int CODE_ORDER_ERROR = 450

Order of files in the deployment package is bad. The right order is the following:

1 META-INF/MANIFEST.MF
2 META-INF/*.SF, META-INF/*.DSA, META-INF/*.RS
3 Localization files
4 Bundles
5 Resources

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.13 public static final int CODE_OTHER_ERROR = 463

Other error condition.

All Deployment Admin methods which throw DeploymentException can throw an exception with this error code if the error condition cannot be categorized.

114.14.5.14 public static final int CODE_PROCESSOR_NOT_FOUND = 464

The Resource Processor service with the given PID (see Resource-Processor manifest header) is not found.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241], DeploymentPackage.uninstall()[p.252] and DeploymentPackage.uninstallForced()[p.252] throws exception with this error code.

114.14.5.15 public static final int CODE_RESOURCE_SHARING_VIOLATION = 461

An artifact of any resource already exists.

This exception is thrown when the called resource processor throws a ResourceProcessorException with the org.osgi.service.deploymentadmin.spi.ResourceProcessorException.CODE_RESOURCE_SHARING_VIOLATION error code.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.16 public static final int CODE_SIGNING_ERROR = 456

Bad deployment package signing.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241] throws exception with this error code.

114.14.5.17 public static final int CODE_TIMEOUT = 465

When a client requests a new session with an install or uninstall operation, it must block that call until the earlier session is completed. The Deployment Admin service must throw a Deployment Exception with this error code when the session can not be created after an appropriate time out period.

DeploymentAdmin.installDeploymentPackage(InputStream)[p.241], DeploymentPackage.uninstall()[p.252] and DeploymentPackage.uninstallForced()[p.252] throws exception with this error code.

114.14.5.18 public DeploymentException(int code, String message, Throwable cause)

code The error code of the failure. Code should be one of the predefined integer values (CODE_X).

message Message associated with the exception

cause the originating exception

- Create an instance of the exception.

114.14.5.19 public DeploymentException(int code, String message)

code The error code of the failure. Code should be one of the predefined integer values (CODE_X).

message Message associated with the exception

- Create an instance of the exception. Cause exception is implicitly set to null.

114.14.5.20 public DeploymentException(int code)

code The error code of the failure. Code should be one of the predefined integer values (CODE_X).

- Create an instance of the exception. Cause exception and message are implicitly set to null.

114.14.5.21 public Throwable getCause( )

Returns Returns the cause.

114.14.5.22 public int getCode( )

Returns Returns the code.

114.14.5.23 public String getMessage( )

Returns Returns the message.

114.14.6 public interface DeploymentPackage

The DeploymentPackage object represents a deployment package (already installed or being currently processed). A Deployment Package groups resources as a unit of management. A deployment package is something that can be installed, updated, and uninstalled as a unit. A deployment package is a reified concept, like a bundle, in an OSGi Service Platform. It is not known by the OSGi Framework, but it is managed by the Deployment Admin service. A deployment package is a stream of resources (including bundles) which, once processed, will result in new artifacts (effects on the system) being added to the OSGi platform. These new artifacts can include installed Bundles, new configuration objects added to the Configuration Admin service, new Wire objects added to the Wire Admin service, or changed system properties, etc. All the changes caused by the processing of a deployment package are persistently associated with the deployment package, so that they can be appropriately cleaned up when the deployment package is uninstalled. There is a strict no overlap rule imposed on deployment packages. Two deployment packages are not allowed to create or manipulate the same artifact. Obviously, this means that a bundle cannot be in two different deployment packagess. Any violation of this no overlap rule is considered an error and the install or update of the offending deployment package must be aborted.

The Deployment Admin service should do as much as possible to ensure transactionality. It means that if a deployment package installation, update or removal (uninstall) fails all the side effects caused by the process should be disappeared and the system should be in the state in which it was before the process.

If a deployment package is being updated the old version is visible through the DeploymentPackage interface until the update process ends. After the package is updated the updated version is visible and the old one is not accessible any more.

114.14.6.1 public boolean equals(Object other)

other the reference object with which to compare.

- Indicates whether some other object is "equal to" this one. Two deployment packages are equal if they have the same deployment package symbolic-name and version.

Returns true if this object is the same as the obj argument; false otherwise.

114.14.6.2 public Bundle getBundle(String symbolicName)

symbolicName the symbolic name of the requested bundle

- Returns the bundle instance, which is part of this deployment package, that corresponds to the bundle's symbolic name passed in the symbolicName parameter. This method will return null for request for bundles that are not part of this deployment package.

  As this instance is transient (i.e. a bundle can be removed at any time because of the dynamic nature of the OSGi platform), this method may also return null if the bundle is part of this deployment package, but is not currently defined to the framework.

Returns The Bundle instance for a given bundle symbolic name.

Throws `SecurityException` – if the caller doesn't have the appropriate `DeploymentAdminPermission`[p.242] with "metadata" action

`IllegalStateException` – if the package is stale

114.14.6.3 public BundleInfo[] getBundleInfos( )

- Returns an array of `BundleInfo`[p.239] objects representing the bundles specified in the manifest of this deployment package. Its size is equal to the number of the bundles in the deployment package.

Returns array of BundleInfo objects

Throws `SecurityException` – if the caller doesn't have the appropriate `DeploymentAdminPermission`[p.242] with "metadata" action

114.14.6.4 public String getHeader(String header)

header the requested header

- Returns the requested deployment package manifest header from the main section. Header names are case insensitive. If the header doesn't exist it returns null.

If the header is localized then the localized value is returned (see OSGi Service Platform, Mobile Specification Release 4 - Localization related chapters).

Returns the value of the header or null if the header does not exist

Throws `SecurityException` – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] with "metadata" action

114.14.6.5 public String getName( )

- Returns the Deployment Pacakage Symbolic Name of the package.

Returns The name of the deployment package. It cannot be null.

114.14.6.6 public String getResourceHeader(String resource, String header)

resource the name of the resource (it is the same as the value of the "Name" attribute in the deployment package's manifest)

header the requested header

- Returns the requested deployment package manifest header from the name section determined by the resource parameter. Header names are case insensitive. If the resource or the header doesn't exist it returns null.

  If the header is localized then the localized value is returned (see OSGi Service Platform, Mobile Specification Release 4 - Localization related chapters).

Returns the value of the header or null if the resource or the header doesn't exist

Throws `SecurityException` – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] with "metadata" action

114.14.6.7 public ServiceReference getResourceProcessor(String resource)

resource the name of the resource (it is the same as the value of the "Name" attribute in the deployment package's manifest)

- At the time of deployment, resource processor service instances are located to resources contained in a deployment package.

  This call returns a service reference to the corresponding service instance. If the resource is not part of the deployment package or this call is made during deployment, prior to the locating of the service to process a given resource, null will be returned. Services can be updated after a deployment package has been deployed. In this event, this call will return a reference to the updated service, not to the instance that was used at deployment time.

Returns resource processor for the resource or null.

Throws `SecurityException` – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] with "metadata" action

`IllegalStateException` – if the package is stale

114.14.6.8 public String[] getResources( )

- Returns an array of strings representing the resources (including bundles) that are specified in the manifest of this deployment package. A string element of the array is the same as the value of the "Name" attribute in the manifest. The array contains the bundles as well.

E.g. if the "Name" section of the resource (or individual-section as the Manifest Specification (http://java.sun.com/j2se/1.4.2/docs/guide/jar/jar.html#Manifest%20Specification) calls it) in the manifest is the following

```
Name: foo/readme.txt
Resource-Processor: foo.rp
```

then the corresponding array element is the "foo/readme.txt" string.

Returns The string array corresponding to resources. It cannot be null but its length can be zero.

Throws SecurityException – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] with "metadata" action

114.14.6.9 public Version getVersion( )

- Returns the version of the deployment package.

Returns version of the deployment package. It cannot be null.

114.14.6.10 public int hashCode( )

- Returns a hash code value for the object.

Returns a hash code value for this object

114.14.6.11 public boolean isStale( )

- Gives back the state of the deployment package whether it is stale or not). After uninstall of a deployment package it becomes stale. Any active method calls to a stale deployment package raise IllegalStateException. Active methods are the following:
  - getBundle(String)[p.250]
  - getResourceProcessor(String)[p.251]
  - uninstall()[p.252]
  - uninstallForced()[p.252]

Returns true if the deployment package is stale. false otherwise

See Also uninstall[p.252] , uninstallForced[p.252]

114.14.6.12 public void uninstall( ) throws DeploymentException

- Uninstalls the deployment package. After uninstallation, the deployment package object becomes stale. This can be checked by using isStale()[p.252] , which will return true when stale.

Throws DeploymentException – if the deployment package could not be successfully uninstalled. For detailed error code description see DeploymentException[p.246] .

SecurityException – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] ("‹filter›", "uninstall") permission.

IllegalStateException – if the package is stale

114.14.6.13 public boolean uninstallForced( ) throws DeploymentException

□ This method is called to completely uninstall a deployment package, which couldn't be uninstalled using traditional means (uninstall()[p.252]) due to exceptions. After uninstallation, the deployment package object becomes stale. This can be checked by using isStale()[p.252] , which will return true when stale.

The method forces removal of the Deployment Package from the repository maintained by the Deployment Admin service. This method follows the same steps as uninstall[p.252] . However, any errors or the absence of Resource Processor services are ignored, they must not cause a roll back. These errors should be logged.

Returns true if the operation was successful

Throws DeploymentException – only DeploymentException.CODE_TIMEOUT[p.248] and DeploymentException.CODE_CANCELLED[p.246] can be thrown. For detailed error code description see DeploymentException[p.246] .

SecurityException – if the caller doesn't have the appropriate DeploymentAdminPermission[p.242] ("‹filter›", "uninstall_forced") permission.

IllegalStateException – if the package is stale

114.15 org.osgi.service.deploymentadmin.spi

Deployment Admin SPI Package Version 1.0. The SPI is used by Resource Processors.

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.deploymentadmin.spi; version=1.0
```

114.15.1 Summary

- DeploymentCustomizerPermission - The DeploymentCustomizerPermission permission gives the right to Resource Processors to access a bundle's (residing in a Deployment Package) private area. [p.253]
- DeploymentSession - The session interface represents a currently running deployment session (install/update/uninstall). [p.255]
- ResourceProcessor - ResourceProcessor interface is implemented by processors handling resource files in deployment packages. [p.256]
- ResourceProcessorException - Checked exception received when something fails during a call to a Resource Processor. [p.259]

114.15.2 public class DeploymentCustomizerPermission extends Permission

The DeploymentCustomizerPermission permission gives the right to Resource Processors to access a bundle's (residing in a Deployment Package) private area. The bundle and the Resource Processor (customizer) have to be in the same Deployment Package.

The Resource Processor that has this permission is allowed to access the bundle's private area by calling the DeploymentSession.getDataFile[p.256] method during the session (see DeploymentSession[p.255]). After the session ends the FilePermissions are withdrawn. The Resource Processor will have FilePermission with "read", "write" and "delete" actions for the returned java.io.File that represents the the base directory of the persistent storage area and for its subdirectories.

The actions string is converted to lowercase before processing.

114.15.2.1 public static final String PRIVATEAREA = "privatearea"

Constant String to the "privatearea" action.

114.15.2.2 public DeploymentCustomizerPermission(String name, String actions)

name Bundle Symbolic Name of the target bundle, must not be null.

actions action string (only the "privatearea" or "*" action is valid; "*" means all the possible actions), must not be null.

□ Creates a new DeploymentCustomizerPermission object for the given name and action.

The name parameter is a filter string. This filter has the same syntax as an OSGi filter but only the "name" attribute is allowed. The value of the attribute is a Bundle Symbolic Name that represents a bundle. The only allowed action is the "privatearea" action. E.g.

```
Permission perm = new DeploymentCustomizerPermis-
sion("(name=com.acme.bundle)", "privatearea");
```

The Resource Processor that has this permission is allowed to access the bundle's private area by calling the DeploymentSession.getDataFile[p.256] method. The Resource Processor will have FilePermission with "read", "write" and "delete" actions for the returned java.io.File and its subdirectories during the deployment session.

Throws IllegalArgumentException – if the filter is invalid, the list of actions contains unknown operations or one of the parameters is null

114.15.2.3 public boolean equals(Object obj)

obj the reference object with which to compare.

□ Checks two DeploymentCustomizerPermission objects for equality. Two permission objects are equal if:

- their target filters are equal (semantically and not character by character) and
- their actions are the same

Returns true if the two objects are equal.

See Also `java.lang.Object.equals(java.lang.Object)`

114.15.2.4 public String getActions( )

- Returns the String representation of the action list.

Returns Action list of this permission instance. It is always "privatearea".

See Also `java.security.Permission.getActions()`

114.15.2.5 public int hashCode( )

- Returns hash code for this permission object.

Returns Hash code for this permission object.

See Also `java.lang.Object.hashCode()`

114.15.2.6 public boolean implies(Permission permission)

permission Permission to check.

- Checks if this DeploymentCustomizerPermission would imply the parameter permission. This permission implies another DeploymentCustomizerPermission permission if:
  - both of them has the "privatearea" action (other actions are not allowed) and
  - their filters (only name attribute is allowed in the filters) match similarly to DeploymentAdminPermission.

  The value of the name attribute means Bundle Symbolic Name and not Deployment Package Symbolic Name here!

Returns true if this DeploymentCustomizerPermission object implies the specified permission.

See Also `java.security.Permission.implies(java.security.Permission)`

114.15.2.7 public PermissionCollection newPermissionCollection( )

- Returns a new PermissionCollection object for storing DeploymentCustomizerPermission objects.

Returns The new PermissionCollection.

See Also `java.security.Permission.newPermissionCollection()`

114.15.3 public interface DeploymentSession

The session interface represents a currently running deployment session (install/update/uninstall).

When a deployment package is installed the target package, when uninstalled the source package is an empty deployment package. The empty deployment package is a virtual entity it doesn't appear for the outside world. It is only visible on the DeploymentSession interface used by Resource Processors. Although the empty package is only visible for Resource Processors it has the following characteristics:

- has version 0.0.0
- its name is an empty string
- it is stale

- it has no bundles (see DeploymentPackage.getBundle(String))
- it has no resources (see DeploymentPackage.getResources())
- it has no headers except DeploymentPackage-SymbolicName and DeploymentPackage-Version (see DeploymentPackage.getHeader(String))
- it has no resource headers (see DeploymentPackage.getResourceHeader(String, String))
- DeploymentPackage.uninstall() throws java.lang.IllegalStateException
- DeploymentPackage.uninstallForced() throws java.lang.IllegalStateException

114.15.3.1 public File getDataFile(Bundle bundle)

bundle the bundle the private area belongs to

□ Returns the private data area of the specified bundle. The bundle must be part of either the source or the target deployment packages. The permission set the caller resource processor needs to manipulate the private area of the bundle is set by the Deployment Admin on the fly when this method is called. The permissions remain available during the deployment action only.

The bundle and the caller Resource Processor have to be in the same Deployment Package.

Returns file representing the private area of the bundle. It cannot be null.

Throws SecurityException – if the caller doesn't have the appropriate DeploymentCustomizerPermission[p.253] ("‹filter›", "privatearea") permission.

See Also DeploymentPackage, DeploymentCustomizerPermission[p.253]

114.15.3.2 public DeploymentPackage getSourceDeploymentPackage( )

□ If the deployment action is an install or an update, this call returns the DeploymentPackage instance that corresponds to the deployment package being streamed in for this session. If the deployment action is an uninstall, this call returns the empty deploymet package (see DeploymentPackage).

Returns the source deployment package

See Also DeploymentPackage

114.15.3.3 public DeploymentPackage getTargetDeploymentPackage( )

□ If the deployment action is an update or an uninstall, this call returns the DeploymentPackage instance for the installed deployment package. If the deployment action is an install, this call returns the empty deploymet package (see DeploymentPackage).

Returns the target deployment package

See Also DeploymentPackage

114.15.4 public interface ResourceProcessor

ResourceProcessor interface is implemented by processors handling resource files in deployment packages. Resource Processors expose their services as standard OSGi services. Bundles exporting the service may arrive in the deployment package (customizers) or may be preregistered (they are installed prevoiusly). Resource processors has to define the service.pid standard OSGi service property which should be a unique string.

The order of the method calls on a particular Resource Processor in case of install/update session is the following:

1 begin(DeploymentSession)[p.257]
2 process(String, InputStream)[p.258] calls till there are resources to process or rollback()[p.258] and the further steps are ignored
3 dropped(String)[p.258] calls till there are resources to drop
4 prepare()[p.258]
5 commit()[p.257] or rollback()[p.258]

The order of the method calls on a particular Resource Processor in case of uninstall session is the following:

1 begin(DeploymentSession)[p.257]
2 dropAllResources()[p.257] or rollback()[p.258] and the further steps are ignored
3 prepare()[p.258]
4 commit()[p.257] or rollback()[p.258]

114.15.4.1 public void begin(DeploymentSession session)

session object that represents the current session to the resource processor

- Called when the Deployment Admin starts a new operation on the given deployment package, and the resource processor is associated a resource within the package. Only one deployment package can be processed at a time.

See Also DeploymentSession[p.255]

114.15.4.2 public void cancel( )

- Processing of a resource passed to the resource processor may take long. The cancel() method notifies the resource processor that it should interrupt the processing of the current resource. This method is called by the DeploymentAdmin implementation after the DeploymentAdmin.cancel() method is called.

114.15.4.3 public void commit( )

- Called when the processing of the current deployment package is finished. This method is called if the processing of the current deployment package was successful, and the changes must be made permanent.

114.15.4.4 public void dropAllResources( ) throws ResourceProcessorException

- This method is called during an "uninstall" deployment session. This method will be called on all resource processors that are associated with resources in the deployment package being uninstalled. This provides an opportunity for the processor to cleanup any memory and persistent data being maintained for the deployment package.

Throws ResourceProcessorException – if all resources could not be dropped. Only the ResourceProcessorException.CODE_OTHER_ERROR[p.259] is allowed.

114.15.4.5 public void dropped(String resource) throws ResourceProcessorException

resource the name of the resource to drop (it is the same as the value of the "Name" attribute in the deployment package's manifest)

- Called when a resource, associated with a particular resource processor, had belonged to an earlier version of a deployment package but is not present in the current version of the deployment package. This provides an opportunity for the processor to cleanup any memory and persistent data being maintained for the particular resource. This method will only be called during "update" deployment sessions.

Throws ResourceProcessorException – if the resource is not allowed to be dropped. Only the ResourceProcessorException.CODE_OTHER_ERROR[p.259] error code is allowed

114.15.4.6 public void prepare( ) throws ResourceProcessorException

- This method is called on the Resource Processor immediately before calling the commit method. The Resource Processor has to check whether it is able to commit the operations since the last begin method call. If it determines that it is not able to commit the changes, it has to raise a ResourceProcessorException with the ResourceProcessorException.CODE_PREPARE[p.259] error code.

Throws ResourceProcessorException – if the resource processor is able to determine it is not able to commit. Only the ResourceProcessorException.CODE_PREPARE[p.259] error code is allowed.

114.15.4.7 public void process(String name, InputStream stream) throws ResourceProcessorException

name The name of the resource relative to the deployment package root directory.

stream The stream for the resource.

- Called when a resource is encountered in the deployment package for which this resource processor has been selected to handle the processing of that resource.

Throws ResourceProcessorException – if the resource cannot be processed. Only ResourceProcessorException.CODE_RESOURCE_SHARING_VIOLATION[p.259] and ResourceProcessorException.CODE_OTHER_ERROR[p.259] error codes are allowed.

114.15.4.8 public void rollback( )

- Called when the processing of the current deployment package is finished. This method is called if the processing of the current deployment package was unsuccessful, and the changes made during the processing of the deployment package should be removed.

114.15.5 public class ResourceProcessorException extends Exception

Checked exception received when something fails during a call to a Resource Processor. A ResourceProcessorException always contains an error code (one of the constants specified in this class), and may optionally contain the textual description of the error condition and a nested cause exception.

114.15.5.1 public static final int CODE_OTHER_ERROR = 463

Other error condition.

All Resource Processor methods which throw ResourceProcessorException is allowed throw an exception with this erro code if the error condition cannot be categorized.

114.15.5.2 public static final int CODE_PREPARE = 1

Resource Processors are allowed to raise an exception with this error code to indicate that the processor is not able to commit the operations it made since the last call of ResourceProcessor.begin(DeploymentSession)[p.257] method.

Only the ResourceProcessor.prepare()[p.258] method is allowed to throw exception with this error code.

114.15.5.3 public static final int CODE_RESOURCE_SHARING_VIOLATION = 461

An artifact of any resource already exists.

Only the ResourceProcessor.process(String, InputStream)[p.258] method is allowed to throw exception with this error code.

114.15.5.4 public ResourceProcessorException(int code, String message, Throwable cause)

code The error code of the failure. Code should be one of the predefined integer values (CODE_X).

message Message associated with the exception

cause the originating exception

- Create an instance of the exception.

114.15.5.5 public ResourceProcessorException(int code, String message)

code The error code of the failure. Code should be one of the predefined integer values (CODE_X).

message Message associated with the exception

- Create an instance of the exception. Cause exception is implicitly set to null.

114.15.5.6 public ResourceProcessorException(int code)

code The error code of the failure. Code should be one of the predefined integer values (CODE_X).

- Create an instance of the exception. Cause exception and message are implicitly set to null.

114.15.5.7 public Throwable getCause( )

Returns Returns the cause.

114.15.5.8 public int getCode( )

Returns Returns the code.

114.15.5.9 public String getMessage( )

Returns Returns the message.

114.16 References

[1] *JAR File Specification*
http://java.sun.com/j2se/1.5.0/docs/guide/jar/jar.html

[2] *OSGi Service Platform Core Specification*
http://www.osgi.org

115 Auto Configuration Specification

Version 1.0

115.1 Introduction

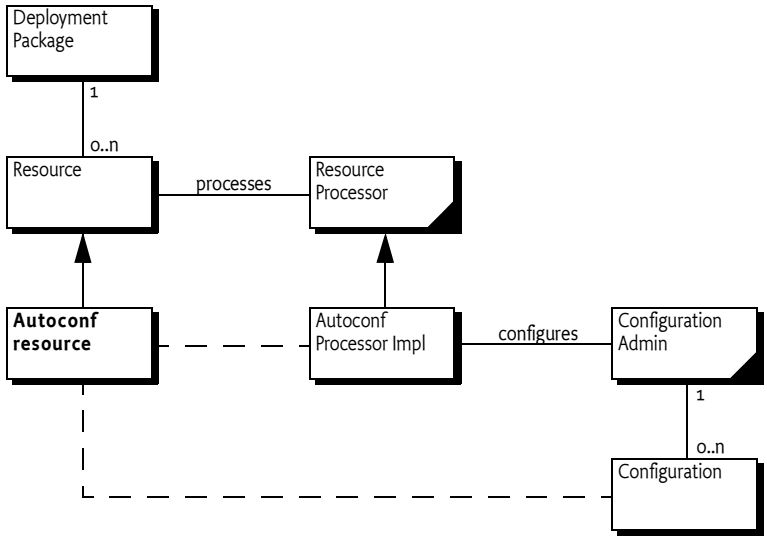
The purpose of the Auto Configuration specification is to allow the configuration of bundles. These bundles can be embedded in Deployment Packages or bundles that are already present on the OSGi Service Platform. This specification defines the format and processing rules of a Autoconf Resource Processor. Resource processors are defined in *Deployment Admin Specification* on page 205.

An Auto Configuration Resource contains information to define `Configuration` objects for the *Configuration Admin Service Specification* on page 71.

115.1.1 Entities

- *Autoconf Resource* – One or more resources in a Deployment Package that are processed by the Autoconf Processor.
- *Deployment Package* – A named and versioned file that groups resources into a single management unit. Deployment packages are the unit of deployment and uninstallation. Deployment packages can contain bundles and associated deployment-time resources that are processed by Resource Processors.
- *Resource Processor* – A deployment-time customizer that accepts a resource in a Deployment Package and turns it into a number of artifacts. A resource processor is a service that implements the `ResourceProcessor` interface.
- *Autoconf Resource Processor* – The Resource Processor that processes the autoconf resources in a Deployment Package.

Figure 115.1 Autoconf Context Diagram



115.1.2 Synopsis

A Deployment Package can contain one or more Autoconf resources. The Manifest of the Deployment Package connects this resource to the Autoconf Resource Processor. When the Deployment Package is deployed, the Autoconf Resource Processor reads the information from the Autoconf resources and creates Configuration objects: both Managed Service as well as Managed Service Factory Configuration objects.

When the Deployment Package is updated or uninstalled, the Autoconf Resource Processor must delete the appropriate Configuration objects.

115.2 Configuration Data

Bundles usually require configuration data when they are deployed. For example, a bundle that has to contact a central server needs one or more server URLs. In practice, a complete application can consist of:

- A number of bundles
- Their configuration data
- Other required resources

The Deployment Package allows such an application to be installed, updated, and uninstalled in a single operation. This specification extends the Deployment Package with a facility to create Configuration objects. The extension uses the Resource Processor mechanism to read one or more resources from the Deployment Package and create Configuration objects based on these resources.

For example, a Deployment Package contains a single bundle Chat. This bundle, when started, registers a Managed Service with a PID of com.acme.pid.Chat. The expected Configuration Dictionary contains a single property: serverurl.

The schema explanation for an Autoconf resource can be found in *Metatype Service Specification* on page 117. An Autoconf resource could look like:

```
<?xml version="1.0" encoding="UTF-8"?>
<metatype:MetaData
   xmlns:metatype=
      "http://www.osgi.org/xmlns/metatype/v1.0.0">

  <OCD id="ChatConfiguration">
    <AD id="server" type="String">
  </OCD>

  <Designate pid="com.acme.pid.Chat"
     bundle="http://www.acme.com/chat.jar>
   <Object ocdref="ChatConfiguration">
      <Attribute adref="server" name="serverurl"
         content="http://chat.acme.com"/>
   </Object>
 </Designate>

</metatype:MetaData>
```

The OCD element (an abbreviation of Object Class Definition) defines the type of the Configuration Dictionary. This typing is based on the *Metatype Service Specification* on page 117. The Designate element links the configuration data to a PID. This PID is the PID for the configuration object. The content is defined in an Object element. An Object element links to an OCD element and defines the values of the attributes in Attribute elements.

The Autoconf Resource Processor in the example is instructed by this resource to create a Managed Service Configuration object with a Dictionary object that contains serverurl="http://chat.acme.com".

An Autoconf resource can configure Managed Service configurations, as long as the bundle is contained in the same Deployment Package. For bundles that are not contained in the Deployment Package, a.k.a. *foreign bundles*, only Managed Service Factory configurations can be created. Configuring foreign bundles with a Managed Service configuration could create ownership conflicts and is therefore explicitly not allowed.

The Autoconf Resource Processor must be able to handle installations, updates, and uninstallations of Deployment Packages.

115.3 Processing

The Autoconf Resource Processor must register itself with the following PID to become available to the Deployment Admin service:

```
org.osgi.deployment.rp.autoconf
```

The Autoconf Resource Processor must process each Designate element in order of appearance. This element has the following information:

- *pid* – The PID of the Configuration object. If the Configuration object is a factory configuration, the PID is actually an alias of the actual PID because a factory configuration PID is generated.

- *factoryPid* – (String) Defines a factory PID when this Designate is a *factory configuration*; otherwise it is for a *singleton configuration*.
- *bundle* – The location of the bundle. It must be used to set the location of the Configuration object. This attribute is mandatory for autoconf though it is not mandatory for the schema because other applications might not need a bundle location.
- *merge* – (true|false) Indicates that the value of the contained Object definition replaces (merge=false) the configuration data, or only replaces properties (merge=true) that do not exist in the configuration data.
- *optional* – (true|false) If true, then this Designate element is optional, and errors during processing must be ignored. Otherwise, errors during processing must abort the installation of the Deployment Package. This requires the undoing of any work done so far.

The content of a Designate element is an Object element. This element contains the value for the configuration Dictionary.

If the Designate element was marked optional, then any errors during these steps can be ignored and the next Designate element must be processed.

A factory configuration is processed differently from a singleton configuration. These two different processing methods are discussed in the following sections.

115.3.1 Factory Configurations

Factory configurations can be created and deleted any number of times. This concept of multiplicity makes it straightforward to associate factory configurations with a Deployment Package. Each Deployment Package can create its unique configurations that are independent of any other Deployment Packages. When the Deployment Package is uninstalled, the created configurations can be deleted without any concern for sharing.

A factory configuration is defined in a Designate element. The factoryPid must be set to the PID of the related Managed Service Factory service. For example:

```
<Designate pid="a" factoryPid="com.acme.a"
          bundle="osgi-dp:com.acme.A">
  <Object ocdref="a">
     <Attribute adref="foo" content="Zaphod Beeblebrox"/>
  </Object>
</Designate>
```

The Autoconf resource cannot use the actual PID of the Configuration object because the Configuration Admin service automatically generates the PID of factory configurations. This created PID is called the *actual* PID.

The Autoconf resource author cannot know the actual PID ahead of time. The Autoconf resource must therefore specify a *alias*. The alias does not have to be globally unique; it must only be unique for a specific Autoconf resource. The Autoconf Processor must maintain the following association (per Autoconf resource):

```
alias → actual PID
```

The alias can be viewed as an Autoconf resource local name for the factory configuration PID. The actual PID is generated when the Autoconf processor creates a new factory configuration. This mapping is identical to the mapping defined for the Configuration Admin Plugin; see *Factory and Singleton Configurations* on page 13.

The alias → actual PID association must be used by the Autoconf Processor to decide what life cycle operation to execute.

- *Alias* → ∅ – This installation is a first-time installation of the factory configuration. The Autoconf resource specifies a factory configuration that was not part of a previous installation. The Autoconf Processor must therefore create a new factory configuration, set the configuration dictionary to the values in the Object element (see *Assigning a Value* on page 267), and create the Alias → Actual association.
- *Alias* → *Actual* – The factory configuration already exists from a previous Autoconf resource installation. The Autoconf Processor must merge or override (depending on the merge attribute) the Configuration object designated by the actual PID with the values in the Object element (see *Assigning a Value* on page 267).
- ∅ → *Actual* – The Autoconf resource no longer contains an alias that it previously contained. The configuration identified by the actual PID must be deleted.

Uninstalling an Autoconf resource requires that the Autoconf Resource Processor deletes all Configuration objects associated with the resource.

115.3.2 Singleton Configuration

A singleton configuration is associated with a Managed Service. The Autoconf Resource Processor must only use singleton configurations for bundles that are contained in the same Deployment Package as the Autoconf resource. The target Deployment Package can provide a list of these bundles.

This ownership policy is required to prevent sharing conflicts. For this reason, the bundle attribute in the Designate element must be set to the location of the bundle so that this ownership is enforced by the Configuration Admin service. The location of the bundle is defined by the Bundle Symbolic Name of the given bundle prefixed with osgi-dp:.

The processing must abort with a fatal error if the bundle attribute is not set. The Autoconf Resource processor must bind the singleton configuration to the given bundle.

If a singleton configuration with a given PID already exists, it must be unbound or bound to the same location contained by the bundle attribute. Otherwise the processing must abort.

The singleton configuration must be merged with or replaced by the information in the Object element, depending on the merge attribute as described in *Assigning a Value* on page 267.

115.3.3 Example

For example, bundle A uses a factory configuration with the factory PID com.acme.a and bundle B uses a singleton configuration with PID com.acme.b. They define the following configuration properties:

```
com.acme.a:
gear                Integer
ratio               Vector of Float

com.acme.b:
foo                 String
bar                 Short[]
```

For proper operation, a Deployment Package P needs a configuration for com.acme.a and com.acme.b with the following values:

```
gear    = 3
ratio   = {3.14159,  1.41421356, 6.022E23}
foo     = "Zaphod Beeblebrox"
bar     = {1,2,3,4,5}
```

The corresponding autoconf.xml resource associated with Deployment Package P would look like:

```
<?xml version="1.0" encoding="UTF-8"?>
<metatype:MetaData
   xmlns:metatype=
      "http://www.osgi.org/xmlns/metatype/v1.0.0">

  <OCD id="a">
    <AD id="gear"  type="Integer" cardinality="0" />
    <AD id="ratio" type="Float" cardinality="-3" />
  </OCD>

  <OCD id="b">
   <AD id="foo"   type="String" cardinality="0"/>
   <AD id="bar"   type="Short" cardinality="5"/>
  </OCD>

  <Designate pid="x" factoryPid="com.acme.a"
     bundle="osgi-dp:com.acme.a">
   <Object ocdref="a">
     <Attribute adref="gear" content="3" />
     <Attribute adref="ratio">
       <Value>3.14159</Value>
       <Value>1.41421356"</Value>
       <Value>6.022E23"</Value>
     </Attribute>
   </Object>
  </Designate>

  <Designate pid="com.acme.b"
     bundle="osgi-dp:com.acme.B">
   <Object ocdref="b">
     <Attribute adref="foo" content="Zaphod Beeblebrox"/>
     <Attribute adref="bar">
       <Value>1</Value>
       <Value>2</Value>
       <Value>3</Value>
```

```
            <Value>4</Value>
            <Value>5</Value>
          </Attribute>
        </Object>
      </Designate>
    </metatype:MetaData>
```

115.3.4 Assigning a Value

The Autoconf resources share a scheme and can cooperate with the *Metatype Service Specification* on page 117. An Autoconf resource primarily contains a number of values for configuration objects in the Designate elements. Designate elements :

- Are for a factory or singleton configuration (factoryPid attribute)
- Are bound to a bundle location (bundle attribute)
- Are meant to be merged with an existing value or replace an existing value (merge attribute). Merging means only setting the values for which the existing Configuration object has no value.
- Provide a value for the Configuration object with the Object element.

Designate elements contain an Object element that contains the actual value. Object elements refer to an OCD element by name. The OCD elements act as a descriptor of the properties.

The OCD elements that are referred from an Object element can be contained in the Autoconf resource, or they can come from the Meta Type service. The reference takes place through the ocdref attribute of the Object element. The Autoconf Resource Processor must first match this name to any OCD elements in the Autoconf resources. If the reference cannot be found in this file, it must consult the Meta Type service (if present) for the bundle that is associated with the PID that is configured.

115.3.5 Process Ordering

The Autoconf Processor must create any factory and singleton configurations when it is called with an Autoconf resource. This phase should perform as much validation as possible. The configurations must be created in the order of appearance in the Autoconf resource.

In the commit method, the Autoconf Resource Processor must first delete all Configuration objects that were uninstalled. Thereafter, it must set or update the appropriate Configuration objects.

This ordering implies that a customizer bundle cannot receive configuration parameters from an Autoconf resource.

115.4 Security Considerations

Allowing a deployment package's Autoconf resources to (re)configure arbitrary configurations creates security threats. The possible threats are discussed in the following sections.

115.4.1 Location Binding

As described in *Configuration Admin Service Specification* on page 71, it is possible for a malicious bundle to register a Managed Service under a PID used by another (legitimate) bundle. This activity essentially *hijacks* the Managed Service PID, and constitutes a denial of service attack on the legitimate bundle (as it never receives the configuration information it needs). The Configuration Admin specification describes a location binding technique that can be used to prevent this attack. The Autoconf Resource Processor must bind Configuration objects to locations specified in the Autoconf resources using the mandatory bundle attribute.

115.4.2 Autoconf Resource Permissions

The capabilities of an Autoconf Resource Processor must be limited to the permissions that are granted to the signer of a Deployment Package. This is the specified way for the Deployment Admin service to act. The Autoconf Resource Processor does not have to take any special actions; all its actions are automatically scoped by the signer of the Deployment Package.

This restriction implies, however, that the Autoconf Resource Processor must do a doPrivileged method for any actions that should not be scoped: for example, when it persists the associations of the alias → actual PID.

A Deployment Package that requires any activity from the Autoconf Resource processor must at least provide ConfigurationPermission[*, CONFIGURE].

116 Application Admin Service Specification

Version 1.0

116.1 Introduction

The OSGi Application Admin service is intended to simplify the management of an environment with many different *types* of applications that are simultaneously available. A diverse set of application types are a fact of life because backward compatibility and normal evolution require modern devices to be able to support novel as well as legacy applications. End users do not care if an application is an Applet, a Midlet, a bundle, a Symbian, or a BREW application. This specification enables applications that manage other applications, regardless of application type. These applications are called *application managers*. This specification supports enumerating, launching, stopping and locking applications. This specification does not specify a user interface or end-user interactions.

The OSGi Service Platform is an excellent platform on which to host different Application Containers. The class loading and code sharing mechanisms available in the OSGi Service Platform can be used to implement powerful and extendable containers for Java based application models with relative ease. Native code based application models like Symbian and BREW can be supported with proxies.

116.1.1 Essentials

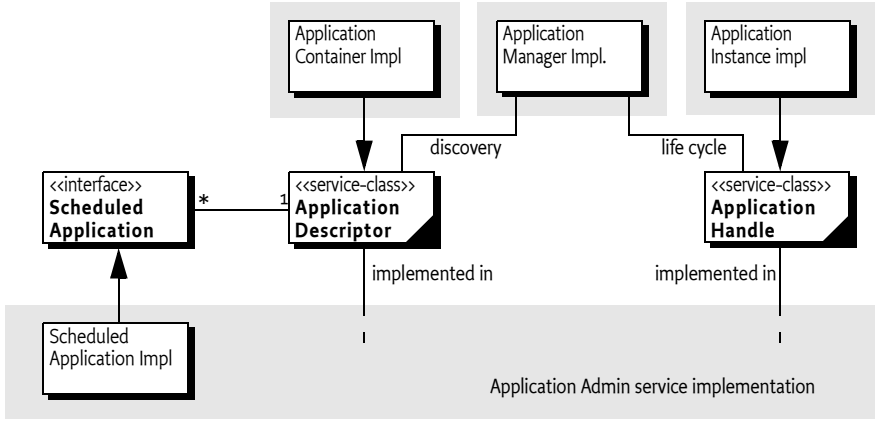
- *Generic Model* - The Application Admin service defines how all applications, regardless of type, can be launched and destroyed. This application-type neutral model allows a screen or desktop manager access to all executable content in a uniform manner.
- *Schedule* - A mechanism that allows the launching of applications at a pre-defined time, interval, or event.
- *Dynamic* - Detects installations and un-installations of applications in real time.
- *Locking* - Allows applications to be persistently locked so that they cannot be launched.

116.1.2 Entities

- *Application* - A software component, which has well-defined entry and exit criteria. Applications can be started and destroyed, and usually are designed for user interaction. Applications may be of various types, each having their own specification. Applications and application instances are visible through the their Application Descriptor services and Application Handle services.

- *Application Container* - An implementation of a runtime environment for one or more application types. It provides specialized Application Descriptor and Application Handle services that correspond to the supported application type and their instances. The design of a particular Application Container is defined by other specifications. For example, an Application Container which implements MIDlets must follow the appropriate JSR specifications for MIDP.
- *Application Handle* - A service that represents an *instance* of an application. This service is available in the OSGi service registry as long as the application instance exists.
- *Application Instance* – The actual application that has been launched. Registered in the service registry as long as the application is running.
- *Application Descriptor* - A service that represents an installed Application and provides information about the application as well as launching, scheduling and locking features. An Application Descriptor must be registered for each application as long as the Application is installed
- *Application Manager* – A bundle that manages a number of applications.
- *Scheduled Application* – An information record for a scheduled application.

Figure 116.1 Application Management Diagram org.osgi.service.application package



116.1.3 Synopsis

Different types of applications can be accommodated in the Application Admin service using a model of Application Containers. An Application Container typically follows an external specification, for example, the MIDP specification. In an OSGi environment, the implementer of such a specification can allow its applications (MIDlets in the previous example) to participate in the OSGi Application Model by registering an Application Descriptor service for each of its installed applications, and an Application Handle service for each of its running instances.

This model leverages the capabilities of the OSGi service registry. Installed applications and running applications can be found by enumerating the appropriate services, possibly using a filter if a specific application is sought.The service registry provides necessary isolation of the clients of the applications and their implementers. Typical clients of this specification are desktop/screen managers that provide the end user access to the installed applications.

116.2 Application Managers

An application manager (a bundle or application that manages other applications) must be able to discover the available applications, present them to an end user and launch applications on demand. A bundle that maintains the display of a mobile phone is a typical client of this specification.

116.2.1 Discovery

The primary means of discovery is the Application Descriptor service. An Application Container must register an Application Descriptor service for each of its applications. An application manager can detect the installation and uninstallation of applications by listening to service events.

Service properties on the Application Descriptor carry most of the information that an application manager requires to present the application to the end user. The properties as defined in Table 116.1.

Table 116.1 Service Properties for an Application Descriptor

Key Name	Type	Default	Description
service.pid	String	*must be set*	Unique identifier of the application. It is recommended to set a value generated from the vendor's reverse domain name, e.g. com.acme.application.chess. The service.pid service property is a standard Framework property.
application.version	String	*empty string*	Specifies the version of the application. The default value is an empty string
service.vendor	String	*empty string*	Specifies the vendor of the application.
application.container	String	*must be set*	A unique identifier (like a PID) of the container implementation that registered this application descriptor.
application.location	String	*must be set*	The identifier of package that contains the application corresponding to this descriptor. It represents the installation unit that contains the corresponding application. It should be a URL. For applications installed as bundles, it should be the location of the bundle. For others, it is defined by the container implementation.

Table 116.1 Service Properties for an Application Descriptor

Key Name	Type	Default	Description
application.visible	Boolean	true	Specifies whether the application should be visible for the user. For example, some applications may provide features to other applications but nothing directly to the user. In this case the application should not be revealed to the user to start it individually.
application.launchable	Boolean	false	Specifies whether the application is ready to be launched. If the value is true, it means that all the requirements of the application are fulfilled.
application.locked	Boolean	false	Specifies whether the represented application is locked to prevent launching it.

Specialized application descriptors can offer further service properties and method. For example, a MIDP container can register a property that describes that the MIDLet comes from a specific JAD file, thereby allowing a MIDLet aware Application Manager to group these MIDLets.

Application Descriptor services must not be declarative. That is. they can be obtained from the service registry at any time without accidentitally initializing a class loader.

The following example shows how to track all visible, launchable, and unlocked applications. These tracked applications are the ones that can be started.

```
public class TrackLaunchables {
   final static String filter=
      "(&(objectclass="
   +  ApplicationDescriptor.class.getName()
   + ")(application.launchable=true)"
   + "(application.visible=true)"
   + "(application.locked=false))";
   static ApplicationDescriptor[] EMPTY =
      new ApplicationDescriptor[0];
   ServiceTracker tracker;

   public void init(BundleContext cntxt) throws Exception {
      tracker = new ServiceTracker(cntxt,
         cntxt.createFilter(filter), null);
      tracker.open();
   }

   public ApplicationDescriptor[] getActive() {
      Object [] result = tracker.getServices();
      List list = Arrays.asList(result);
      return (ApplicationDescriptor[]) list.toArray(EMPTY);
   }
}
```

The code is quite simple because the Service Tracker does the actual tracking. The most important part is therefore the filter. The filter selects all the Application Descriptor services that are visible, launchable, and not locked. The getActive method converts the Object[] that the Service Tracker maintains into an array of Application Descriptors.

116.2.2 Application Descriptor Properties

The Application Descriptor object has an additional number of properties that are not available as service properties. These descriptor properties can be localized. The getProperties(String) method therefore takes a *locale* String object. This is a standard locale string as defined by the java.util.Locale class. The order for the locale constituents is:

- language
- country
- variant

For example, the following files provide manifest translations for English, Dutch (Belgium and the Netherlands) and Swedish.

```
en          nl_BE
nl_NL       sv
```

It returns a Map object containing localized versions of the properties. This is a copy of the original objects so changes to this Map object are not reflected in the Application Descriptor properties.

If the locale string is null, the localization will be based on the default locale, as specified by the java.util.Locale.getDefault method. If the locale is the empty String object (""), no localization must be used. This will contain the raw values that are usually used as keys. If a specific locale has no appropriate translations, a less specific locale must be used, as described in the Locale class. As last resort, the raw values must be returned.

The key names in the Map object are case-sensitive. Application Containers can add additional properties to this Map object, however, they must avoid key names starting with application. They should use key names that have a prefix that does not collide with other Application Containers.

If no locale specific value of an application property is available then the default one must be returned. The following case-sensitive key names are treated as standard for locale specific values in the Map object. Additional elements may also be stored in the Map object. The specified properties are explained in Table 116.2.

Table 116.2 Descriptor localized properties

Key Name	Type	Default	Description
application.name	String	*must be set*	The name of the application.
application.icon	URL	*No Icon*	A URL an icon's image resource. A compliant implementation of this specification must support the [1] *PNG Image Format.*
application.version	String	*0.0.0*	The version of the application

Table 116.2 Descriptor localized properties

Key Name	Type	Default	Description
service.vendor	String		The vendor of the application
application.visible	Boolean	true	
application.launchable	Boolean	true	If the application can be launched
application.locked	Boolean	true	If the application is locked
application.description	String		A description of the application
application.documentation	String		Document
application.copyright	String		A Copyright statement
application.license	String		A URL to the license related to the application
application.container	String	*must be set*	The PID of the associated container
application.location	String		The URL of the location of the corresponding JAR file of the application, if exists.

116.2.3 Launching

The Application Descriptor provides the launch(Map) methods for application managers to launch an application. Launching consists of creating the specific application object, starting it, registering an Application Handle service that represents that instance and return the Application Handle service.

The Map object parameter is application specific. Applications should use unique names for the keys in this map, for example com.acme.ringsignal. This specification does not specify any keys for this map except for:

- org.osgi.triggeringevent – This property is set to the Event object that cause the application to be launched (if any).

When an application is started successfully the corresponding Application Handle service will be registered with the service registry.

116.2.4 Application States

An Application Handle service represents an instance of an application. The application handle is registered by the Application Container after successfully launching a new application instance.

An Application Handle service can be used to query the state and manipulate the application instance. It is the responsibility of the Application Handle service to maintain the application instance life cycle state by interacting with the implementation object of the application.

A running instance can have the following state according to this specification:

- RUNNING – This is the state of the Application Handle when it gets registered. It indicates that the application instance is active.
- STOPPING – The application is stopping. This is a transient state.

Application Containers can extend the number of states.

The Application Handle service maintains the service properties as listed in Table 116.2. Specialized application handles may offer further service properties, but the key names specified in the table below must not be used for other purposes.

Table 116.3 Application Handle service properties

Key Name	Type	Default	Description
service.pid	String	*must be set*	The Application Instance ID as returned by the getInstanceId method.
application.state	String	*must be set*	Contains the current state of the application instance represented by this application handle. These states can be application model specific.
application.descriptor	String	*must be set*	The PID of the associated Application Descriptor service

Specialized application handles may offer further application states. The name of additional states must be qualified names (dotted); non-qualified names are reserved for future specifications.

116.2.5 Destroying an Application Instance

An application instance can be stopped with its associated Application Handle using the destroy() method. This first turns the state of the Application to STOPPING. The application instance may save its persistent data before termination and it must release all the used resources. The application instance's artifacts should not be reused any more. The Application Admin service and the application container should ensure (even forcefully) that all allocated resources are cleaned up.

If the application instance has completely stopped, then its Application Handle must be unregistered.

116.2.6 Locking an Application

Applications represented by the application descriptors can be locked. If an application is locked then no new instance of the represented application can be started until it is unlocked. The locking state of the application has no effect on the already launched instance(s). The Application Descriptor provides the methods lock and unlock to set, unset the locking state. Locking and unlocking an application represented by an Application Descriptor requires the proper Application Admin Permission. The methods to lock, unlock, and query the locked status of an application are implemented as final methods of the abstract application descriptor class to ensure that an application container implementation will not be able to circumvent this security policy.

116.2.7 Scheduling

Scheduling can be used to launch an a new application instance in the future when a specific event occurs, if needed on a recurring basis.

The Application Descriptor service provides the schedule(String,Map, String,String,boolean) method to schedule an application to be launched when an specific event occurs. The parameters to this method are:

- *Schedule Id* – (String) An id for this application that identifies the schedule, even over system restarts. Ids must be unique for one application. This id will be registered as service property on the Scheduled Application service under the name of SCHEDULE_ID. The name must match the following format:

```
scheduleId ::= symbolic-name
           // Core 1.4.2 General Syntax Definitions
```

- *Arguments* – (Map) These arguments will be passed to the application in the launch method. The keys in this map must not be null or the empty string.
- *Topic* – (String) The topic of the event that must trigger the launch of the application.
- *Filter* – (String) A filter that is passed to the Event Admin for subscribing to specific events, can be null. The syntax of the string is the same as an OSGi Framework filter.
- *Recurring* – (boolean) Repeatedly launch the application when the specified events occur until the schedule is canceled.

The schedule method must register a Scheduled Application service with the service registry and return the Schedule Application service object.

For example, the invocation

```
appDesc.schedule(
   null,      // System generates schedule id
   null,      // No arguments
   "org/osgi/application/timer",
   "(&(hour_of_day=0)(minute=0))",
   true)
```

Schedules the application to be launched when a timer event is received and the hour_of_day and minute properties are zero.

The Scheduled Application service must have the following properties:

- APPLICATION_PID - (String) The PID of the Application Descriptor service.
- SCHEDULE_ID- (String) a unique id (within the schedules for one application).

The list of active Scheduled Application services can be obtained from the service registry. A non-recurrent Scheduled Application service is unregistered once the application is succesfully launched.

The timer used to start an application from a schedule has a resolution of one minute. It is therefore possible that an application is delayed up to a minute before it is started.

116.2.8 Application Exceptions

Exceptional conditions that arise during processing of application requests. The Exception identifies the actual error with an integer code. The following codes are supported:

- APPLICATION_INTERNAL_ERROR – An internal error occurred.

- APPLICATION_LOCKED – The application is locked and can therefore not be launched.
- APPLICATION_NOT_LAUNCHABLE – The application could not be launched.
- APPLICATION_SCHEDULING_FAILED – The application scheduling could not be created due to some internal error . This entails that the the scheduling information is not persisted.
- APPLICATION_DUPLICATE_SCHEDULE_ID – The application scheduling failed because the specified identifier is already in use.

116.2.9 Application Events

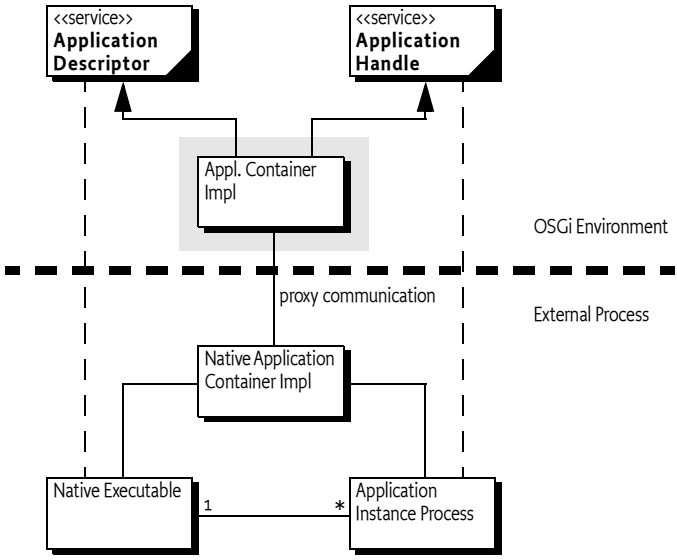
The event mechanism of the Application Admin service is based on the OSGi service registry event model. Both Application Descriptor and Application Handle are services. Bundles can listen to these events registering a ServiceListener object with a Bundle Context or they can listen to events from the Event Admin, see for more information *Service Event* on page 195.

- Application Descriptor service
  - REGISTERED – A new application has become available. Depending on its properties, this application could be launched.
  - MODIFIED – The visibility, launchable or locked status is changed.
  - UNREGISTERING – The application is no longer available. All running instances of this application must be destroyed before this event is delivered.
- Application Handle service
  - REGISTERED – A new instance is created and started running.
  - MODIFIED – The application instance is changed its state. This specification only specifies the STOPPING state but application containers are free to add additional states. Transitions between all these states must be signalled with the MODIFIED service event.
  - UNREGISTERING – The application instance is no longer running.

116.3 Application Containers

Application Containers provide the implementation of a specific application model like MIDP, BREW,.NET, or Symbian. Application Containers can be implemented inside the OSGi environment or run externally, in another VM or as native code. When the container runs externally, it is necessary to run a proxy inside the OSGi environment that communicates with the external container. This is shown in Figure 116.2.

Figure 116.2 Application Container Model with Proxy



116.3.1 The Application Descriptor

The first responsibility of the Application Container is to register an Application Descriptor for each available application. The Application Container must therefore extend the ApplicationDescriptor base class that is provided by the Application Admin service implementer and provided in the org.osgi.service.application package. The base class is defined as an abstract class in this specification with only minimal implementation code. Implementers of the Application Admin service implementation can replace this class with an implementation that enforces their desired policies.

The Application Container must override the methods that have a Specific suffix. These methods are:

- ApplicationDescriptor(String) – The Base class Application Descriptor takes the PID of the Application Descriptor as argument.
- getPropertiesSpecific(String) – Return the properties (including service properties) based on a specific locale. See the locale rules at *Application Descriptor Properties* on page 273. The Application Container must fill the returned Map object with the properties listed in Table 116.2 on page 273 as well as other service properties. Non-localized data is returned if the corresponding application container doesn't support the localization of application properties. Changes in the Map object must not be reflected in Application Descriptor properties.
- launchSpecific(Map) – Launch a new instance and return its handle. The container must ensure that the application is started in a doPrivileged block I.e. the permissions of the caller must not influence the capabilities of the started application.
- lockSpecific() – Do the specific locking of the Application Descriptor.

- unlockSpecific() – Do the specific unlocking of the Application Descriptor.
- isLaunchableSpecific() – This method must return true when the application can be launched. This method can be called by the Application Descriptor implementation to find out if an application can be launched according to the container.

The specific methods must be made protected because the specific Application Descriptor is registered as a service and is intended to be used by a wide array of clients. These clients can call public methods so care should be taken to ensure that no intrusion can take place this way. The Application Admin service implementer must provide the implementation for the public methods and perform the appropriate security checks.

The specific Application Descriptor must be registered for each possible application with the set of service properties listed in Table 116.1 on page 271.

An application is launched with the launchSpecific method. This method is called by the Application Admin service, as implemented in the ApplicationDescriptor base class. The implementation of the launchSpecific method must return expediently. The Application Descriptor must perform the following steps (in the given order):

1 Create a new instance of the associated application
2 Start the application in another process or thread.
3 If the application cannot be started, an appropriate Exception must be thrown.
4 Register an Application Handle for this running application. The registration of the Application Handle must be accompanied by the service properties from Table 116.3 on page 275.
5 Return the new Application Handle.

116.3.2 The Application Handle

The Application Handle represents the running instance. The Application Container must extend the provided base class and implement the following methods:

- ApplicationHandle(String,ApplicationDescriptor) – The constructor of the base class takes the executable id and the Application Descriptor as parameter.
- destroySpecific() – Clients of the Application Admin service use the destroy method on the Application Handle service to make an application instance quit. The Application Admin service implements this method and must at an appropriate time call the destroySpecific method. The Application Container must destroy the application instance (if it had not destroyed already) and clean up.
- getApplicationDescriptor() – Return the Application Descriptor that belongs to this Application Handle.
- getInstanceId() – A unique id for this instance.
- getState() – Returns the state for the instance. The Application Admin service only specifies two states: RUNNING and STOPPING. Application Containers can add new states to represent for example PAUSED. States

are strings and must be qualified to prevent conflicts. For example, the Midlet state for paused could be MIDLET.PAUSED.

The most important method is destroySpecific. This method must perform the following actions in the given order:

1 Set the state to STOPPING
2 Modify the service properties of the Service Handle to reflect the new state. This sends out a service event.
3 If the application instance is active, use any proprietary mechanism to stop it. Any errors and problems should be logged.
4 Using proprietary means, clean up any resources on the system that were used by the application: locks, open files, etc.
5 Unregister the Application Handle service.

The Application container should monitor the progress of its instances. If an instance stops, for example due an exception or it quits voluntarily, the Application Container must call the destroy method on the Application Handle itself and handle the fact correctly that the instance is already stopped in the destroySpecific method.

116.3.3 Certificates

The following method on the Application Descriptor provides access to the certificate chain that was used to sign the application. This method is used by the Application Permission.

- matchDNChain(String) – Verifies that the given pattern matches one or more of the certificates that were used to sign the application. This method is primarily used by the Application Admin Permission to verify permissions. Matching certificates is described in *Certificate Matching* on page 21 of the OSGi Release 4 Core Specification.

116.3.4 Application Descriptor Example

This is an Application Container that scans a directory for executables. Each executable is registered as an Application Descriptor. The example assumes that there is a bundle activator that creates the Application Descriptor services. This activator must also ensure that when it is stopped no handles remain.

The example is not an robust implementation, its onl intention is to show the concepts of the Application Admin service in practice.

The (simple) Application Descriptor could look like:

```
public class SimpleDescriptor extends ApplicationDescriptor{
   ServiceRegistration  registration;
   File                 executable;
   SimpleModel          model;
   boolean              locked;
   static URLgenericIcon= SimpleDescriptor.class
                              .getResource("icon.png");

   SimpleDescriptor(SimpleModel model, File executable) {
      super("com.acme." + executable.getName());
      this.model = model;
```

```
      this.executable = executable;
   }

   public Map getPropertiesSpecific(String locale) {
      Map map = new Hashtable();
      map.put(APPLICATION_ICON, genericIcon);
      map.put(APPLICATION_NAME, executable.getName());
      return map;
   }

   protected ApplicationHandle launchSpecific(
      final Map args) throws Exception {
      final SimpleDescriptor descriptor = this;

      return (ApplicationHandle) AccessController
           .doPrivileged(new PrivilegedExceptionAction() {
              public Object run() throws Exception {
                 SimpleHandle handle =
                    new SimpleHandle(descriptor, args);
                 handle.registration =
                    model.register(handle);
                 return handle;
              }
           });
   }

   Dictionary getServiceProperties() {
      Hashtable p = new Hashtable();
      p.put(APPLICATION_LAUNCHABLE, Boolean.TRUE);
      p.put(APPLICATION_LOCKED, Boolean.valueOf(locked));
      p.put(Constants.SERVICE_PID, getApplicationId());
      return p;
   }

   protected void lockSpecific() {locked = true; }
   protected void unlockSpecific() { locked = false; }
   public boolean matchDNChain(String arg) { return false; }
   protected boolean isLaunchableSpecific() { return true; }
}
```

The associated Application Handle must launch the external executable and track its process. If the process dies autonomously or is stopped via the destroy method, it must unregister the Application Handle service. The class could be implementedlike:

```
public class SimpleHandle extends
   ApplicationHandle implements Runnable {

   ServiceRegistration  registration;
   Process              process;
   int                  instance;
   String               state = RUNNING;
   static int           INSTANCE= 0;
```

```
    Thread                thread;

    public SimpleHandle(SimpleDescriptor descriptor,
       Map arguments) throws IOException {
       super(descriptor.getApplicationId()
          + ":" + (INSTANCE++), descriptor);
       String path = descriptor.executable.getAbsolutePath();
       process = Runtime.getRuntime().exec(path);
       thread = new Thread(this, getInstanceId());
       thread.start();
    }

    public String getState() {return state; }

    protected void destroySpecific() throws Exception {
       state = STOPPING;
       registration.setProperties(getServiceProperties());
       thread.interrupt();
    }

    // Wait until process finishes or when
    // interrupted
    public void run() {
       try {
          process.waitFor();
          destroy();
       }
       catch (InterruptedException ie) {
          process.destroy();
          try {
             process.waitFor();
          }
          catch (InterruptedException iee) {
             // Ignore
          }
       }
       catch( Exception e ) {
          .. logging
       }
       registration.unregister();
    }

    Dictionary getServiceProperties() {
       Hashtable p = new Hashtable();
       p.put(APPLICATION_PID, getInstanceId());
       p.put(APPLICATION_STATE, state);
       p.put(APPLICATION_DESCRIPTOR,
          getApplicationDescriptor().getApplicationId());
       return p;
    }
 }
```

The Application Container must create the Application Descriptor services from some source. Care should be taken to optimize this scanning so that the initialization time is not significantly increased. Running application instances should be stopped if the Application Container is stopped. The following code shows a possible implementation:

```
public class SimpleModel implements BundleActivator {
   BundleContext        context;
   Set                  handles= new HashSet();

   public ServiceRegistration register(SimpleHandle handle){
      handles.add(handle);
      return context.registerService(
         ApplicationHandle.class.getName(),
         handle, handle.getServiceProperties());
   }

   public void start(BundleContext context) throws Exception
   {
      this.context = context;

      File file = new File("c:/windows");
      final SimpleModel me = this;

      file.list(new FilenameFilter() {
         public boolean accept(File dir, String name) {
            if (name.endsWith(".exe")) {
               SimpleDescriptor sd = new SimpleDescriptor(me,
                  new File(dir, name));
               sd.registration = me.context.registerService(
                     ApplicationDescriptor.class.getName(),
                        sd, sd.getServiceProperties());
            }
            // We ignore the return anyway
            return false;
   }});}

   public void stop(BundleContext context) throws Exception{
      for (Iterator handle = handles.iterator();
         handle.hasNext();) {
         SimpleHandle sh = (SimpleHandle) handle.next();
         try {
            sh.destroy();
         }
         catch (Exception e) {
            // We are cleaning up ...
         }
}}}
```

116.4 Application Admin Implementations

116.4.1 Implementing the Base Classes

The OSGi specified org.osgi.service.application package that is delivered with the specication in a JAR file is a dummy implementation. The intention of this package is to be replaced by an Application Admin service implementation. This implementation can then enforce policies by intercepting the calls from any Application Managers to the Application Containers.

The Application Admin service implementer must re-implement the following methods in the ApplicationDescriptor class:

- launch(Map) – The method can perform any checks before it must call the launchSpecific(Map) method. This must be a protected method. The implementation must perform any security checks. If these succeed, the launchSpecific method must not be called in a doPrivileged block.
- lock() – Must call the lockSpecific method.
- unlock() – Must call the unlockSpecific method.
- schedule(String,Map,String,String,boolean) – Register a new Scheduled Application service with the given arguments, thereby scheduling the application for launching when the topic and filter match an event. A virtual event is defined for timer based scheduling, see *Virtual Timer Event* on page 286.

The Application Admin service implementer must also implement the following method in the ApplicationHandle class:

- destroy() – The Application Admin service should call the protected destroySpecific() method after which it should perform any possible cleanup operations.

Implementers must not change the signature of the public and protected parts of the ApplicationDescriptor and ApplicationHandle classes. Adding fields or methods, either public or protected is explicitly forbidden.

116.4.2 Exception Handling

The implementation of the container must ensure that Security Exceptions are only thrown during the invocation of any of the Application Descriptor methods when the required permissions are lacking. If the Application Descritor is not valid, an Illegal State Exception must be thrown and never a Security Exception.

116.4.3 Launching

The launch method of the Application Descriptor must be implemented by the Application Admin service implementer. Launching must be performed in the following steps:

1 Verify that the caller has the appropriate permissions, see *Security* on page 288.
2 Verify that the Application Descriptor is not locked and launchable
3 Perform any policy actions that are deemed necessary before the application is really launched.

4 Call the protected launchSpecific method. If the method throws an Exception, then this exception should be logged, and must be re-thrown.
5 Otherwise, return the received Application Handle

116.4.4 Destroying

The implementation of the ApplicationHandle destroy method must follow the following steps:

1 Verify that the caller has the appropriate permissions, see *Security* on page 288.
2 Call the destroySpecific method. If an Exception is thrown, then this should be logged but must be further ignored.
3 Perform any cleanup deemed necessary.

116.4.5 Scheduling

Application Descriptor services can be scheduled by calling the schedule method, as described in *Scheduling* on page 275. This method must be implemented by the Application Admin service implementer.

Application Admin service implementations must make a reasonable effort to launch scheduled applications in a timely manner. However, launching is not guaranteed, implementations can drop and forget events if it is necessary in order to preserve the stability and integrity of the device. The granularity of the timer should also be taken into account, this granularity is one minute so the actual time an application will be launched can be shifted up to 60 seconds.

If an event would launch multiple applications then the order of launching is not defined, it is implementation specific.

Launching a scheduled application is constrained by the same rules as application launching. Thus, attempting to launch a locked application on the specified event must fail to launch. Launching can only succeed when the application is unlocked.

If the scheduling is non-recurring and launching a new instance fails then when the specified event occurs again launching the application must be attempted again until it succeeds. Non recurring schedules must be removed once the launch succeeds.

The triggering event will be delivered to the starting application instance as an additional item identified by the org.osgi.triggeringevent argument in its startup parameters. This property must not be used for other purposes in the startup parameters. To ensure that no events are leaked to applications without the apropriate permission, the event is delivered in a java.security.GuardedObject, where the guarding permission is the Topic Permission for the topic to which the event was posted.

Scheduling and unscheduling an application, or retrieving information about scheduled applications requires the Application Admin Permission for the target application to be scheduled. If the target is the unique identifier of the scheduling application itself then it can schedule itself. In addition, the scheduling entity must have Topic Permission for the specified topic.

116.4.6 Virtual Timer Event

The application scheduler can use a virtual timer event for time scheduled applications. This event is not actually sent out by the Event Admin; this virtual event is only used for the syntax to specify a recurring launch.

The topic name of this virtual timer event is:

```
org/osgi/application/timer
```

The properties of the virtual timer event are:

- year – (Integer) The year of the specified date. The value is defined by Calendar.YEAR field.
- month - (Integer) The month of the year. The value is defined by Calendar.MONTH field.
- day_of_month – (Integer) The day of the month. The value is defined by the Calendar.DAY_OF_MONTH field.
- day_of_week – (Integer) The day of the week. The value is defined by the Calendar.DAY_OF_WEEK field.
- hour_of_day – (Integer) The hour of the day. The value is defined by the Calendar.HOUR_OF_DAY field.
- minute – (Integer) The minute of the hour. The value is defined by the Calendar.MINUTE field.

The timer has a resolution of a minute. That is, it is not possible to schedule per second.

A property that is not included into the filter matches any value. Not including a field implies that it always matches. For example, if the minute=0 clause from the filter is missing, the timer event will be fired every minute.

The following examples are filters for the timer event to specify certain time in the device local time. The topic is always org/osgi/application/timer.

Noon every day:

```
(&(hour_of_day=12)(minute=0))
```

Every whole hour, on every sunday:

```
(&(day_of_week=0)(minute=0))
```

Every whole hour:

```
(minute=0)
```

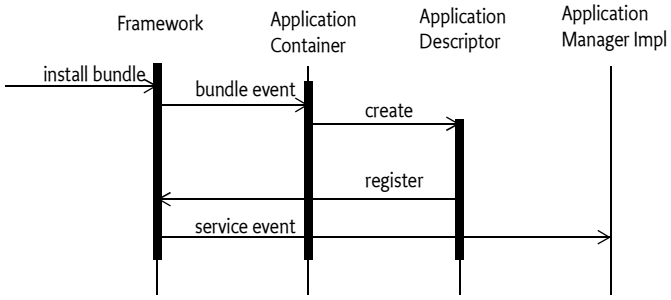
116.5 Interaction

116.5.1 Application Installation

Figure 116.3 shows how an application manager can be notified about the installation of a new application. The actual installation may be done prior to the notification or may be done by the application container. At the end of the successful installation the application container must register a specialized Application Descriptor service which properly represents the

installed application. If the installed application's dependencies are fulfilled (which are container specific) then the application descriptor's application.visible and application.launchable properties should be set to true.

Figure 116.3 Installing a bundle that is managed by an Application Contaner



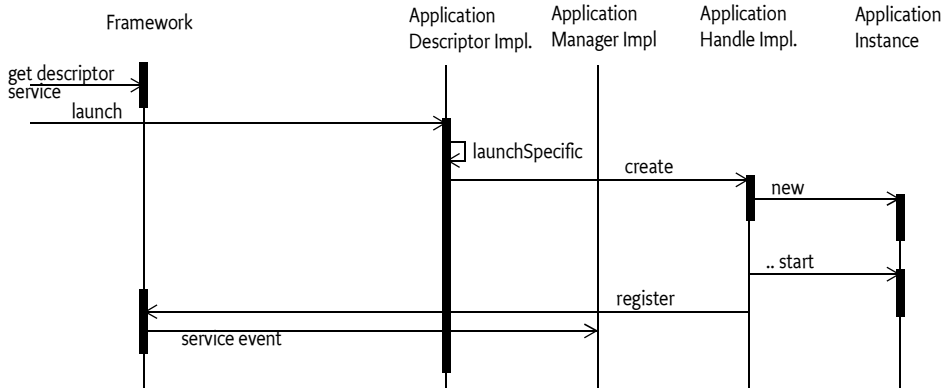
116.5.2 Launching an Application

Firstly the appropriate Application Descriptor service on which the operation will be made is fetched from the service registry. This Application Descriptor is a container specific sub-class of the Application Descriptor class. Its launch method is called which is in the base class.

The application instance may not receive the startup arguments if its application container does not support startup arguments. The launch method checks if the a new application instance can be launched, for example, that the necessary rights are granted, the application is not locked and the application is not a singleton that already has an instance.

If the application can be launched then the launchSpecific method, which is in the subclass, will create and start a new application instance according to its application container. It will create a specific application handle and associate the newly created application instance to it. The launchSpecific method will register the application handle with proper service properties. The value of application.state service property must be RUNNING. The call chain returns the application handle.

Figure 116.4 Launching an application



116.5.3 Destroying an Application Instance

To destroy an application, the proper application handle has to be fetched from the service registry to call its destroy() method. It checks if the instance can be destroyed, for example that the necessary permissions are granted, it then calls the destroySpecific method to let its implementation destroy the instance in an application container specific way. First, it sets the application.state service property to STOPPING then stops the application instance. Finally it unregisters the application handle.

116.6 Security

The Application Admin service is an interaction of the:

- *Application Container implementers*
- *Applications*
- *Application Managers*

There are two permissions used in the security model of the Application Admin service. The first is the Service Permission that grants access to getting or registering the Application Descriptor and Application Handle services. The second security is specific for the Application Admin service specification and is the Application Permission.

The Application Container must be very powerful because it starts the application code, which should be able to perform almost any function.

The security checks are performed in the ApplicationDescriptor and ApplicationHandle base classes.

116.6.1 Application Admin Permissions

This ApplicationAdminPermission class implements permissions for manipulating applications and their instances. The permission must be held by any bundle that manipulates application descriptors or application handles.

The target of the Application Admin Permission is an OSGi filter that matches a number of properties. This is similar to the Admin Permission in the Framework. Alternatively, instead of the filter the pseudo target <<SELF>> can be used.

The following properties can be tested in the filter:

- *signer* – A Distinguished Name chain that is used to sign the application. The matching of this property must be done according to the rules described for DN matching in the OSGi Core Service Platform specification. The Application Admin Permission must use the ApplicationDescrptor class' matchDNChain method. Matching DN's is described in *Certificate Matching* on page 21 of the OSGi Service Platform Core specification.
- *pid* – The PID of the target application.

The pseudo target <<SELF>> indicates that the calling application is allowed to manipulate its own descriptors and handlers.

The following actions can be granted:

- SCHEDULE_ACTION – The caller is allowed to schedule an application., i.e. call the ApplicationDescriptor schedule method. This action implies LIFECYCLE_ACTION.
- LIFECYCLE_ACTION – The caller is allowed to manipulate the life cycle state of an application instance: launch and destroy.
- LOCK_ACTION – The caller is allowed to the lock and unlock methods.

116.6.2 Service and Package Permissions

116.6.2.1 Application Admin Implementation

The Application Admin service implementation must have the following permissions:

```
ServicePermission  ..ScheduledApplication          REGISTER
ServicePermission  ..ApplicationDescriptor         GET
ServicePermission  ..ApplicationHandle             GET
PackagePermission  org.osgi.service.application    EXPORT
ServicePermission  ..ApplicationDescriptor         GET
ServicePermission  ..ApplicationHandle             GET
ApplicationAdminPermission *                       *
```

116.6.2.2 Application Container

```
ServicePermission  ..ApplicationDescriptor         REGISTER
ServicePermission  ..ApplicationHandle             REGISTER
PackagePermission  org.osgi.service.application    IMPORT
```

Additionally, an Application Container requires all the permissions that are needed to run the applications. This is likely to be All Permission.

116.7 org.osgi.service.application

Application Package 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.application; version=1.0
```

116.7.1 Summary

- ApplicationAdminPermission - This class implements permissions for manipulating applications and their instances. [p.289]
- ApplicationDescriptor - An OSGi service that represents an installed application and stores information about it. [p.291]
- ApplicationException - This exception is used to indicate problems related to application lifecycle management. [p.297]
- ApplicationHandle - ApplicationHandle is an OSGi service interface which represents an instance of an application. [p.298]
- ScheduledApplication - It is allowed to schedule an application based on a specific event. [p.300]

116.7.2 public class ApplicationAdminPermission extends Permission

This class implements permissions for manipulating applications and their instances.

ApplicationAdminPermission can be targeted to applications that matches the specified filter.

ApplicationAdminPermission may be granted for different actions: lifecycle, schedule and lock. The permission schedule implies the permission lifecycle.

116.7.2.1 public static final String LIFECYCLE_ACTION = "lifecycle"

Allows the lifecycle management of the target applications.

116.7.2.2 public static final String LOCK_ACTION = "lock"

Allows setting/unsetting the locking state of the target applications.

116.7.2.3 public static final String SCHEDULE_ACTION = "schedule"

Allows scheduling of the target applications. The permission to schedule an application implies that the scheduler can also manage the lifecycle of that application i.e. schedule implies lifecycle

116.7.2.4 public ApplicationAdminPermission(String filter, String actions) throws InvalidSyntaxException

filter filter to identify application. The value null is equivalent to "*" and it indicates "all application".

actions comma-separated list of the desired actions granted on the applications or "*" means all the actions. It must not be null. The order of the actions in the list is not significant.

□ Constructs an ApplicationAdminPermission. The filter specifies the target application. The filter is an LDAP-style filter, the recognized properties are signer and pid. The pattern specified in the signer is matched with the Distinguished Name chain used to sign the application. Wildcards in a DN are not matched according to the filter string rules, but according to the rules defined for a DN chain. The attribute pid is matched with the PID of the application according to the filter string rules.

If the filter is null then it matches "*". If actions is "*" then it identifies all the possible actions.

Throws `InvalidSyntaxException` – is thrown if the specified filter is not syntactically correct.

`NullPointerException` – is thrown if the actions parameter is null

See Also `ApplicationDescriptor`[p.291], `org.osgi.framework.AdminPermission`

116.7.2.5 public ApplicationAdminPermission(ApplicationDescriptor application, String actions)

application the tareget of the operation, it must not be null

actions the required operation. it must not be null

- This contructor should be used when creating ApplicationAdminPermission instance for checkPermission call.

Throws `NullPointerException` – if any of the arguments is null.

116.7.2.6 public boolean equals(Object with)

116.7.2.7 public String getActions( )

- Returns the actions of this permission.

Returns the actions specified when this permission was created

116.7.2.8 public int hashCode( )

116.7.2.9 public boolean implies(Permission otherPermission)

otherPermission the implied permission

- Checks if the specified permission is implied by this permission. The method returns true under the following conditions:
  - This permission was created by specifying a filter (see ApplicationAdminPermission(String, String)[p.290])
  - The implied otherPermission was created for a particular ApplicationDescriptor[p.291] (see ApplicationAdminPermission(ApplicationDescriptor, String)[p.290])
  - The filter of this permission mathes the ApplicationDescriptor specified in the otherPermission. If the filter in this permission is the ‹‹SELF›› pseudo target, then the currentApplicationId set in the otherPermission is compared to the application Id of the target ApplicationDescriptor.
  - The list of permitted actions in this permission contains all actions required in the otherPermission

Returns true if this permission implies the otherPermission, false otherwise.

116.7.2.10 public ApplicationAdminPermission setCurrentApplicationId(String applicationId)

applicationId the ID of the current application.

- This method can be used in the java.security.ProtectionDomain implementation in the implies method to insert the application ID of the current application into the permission being checked. This enables the evaluation of the ‹‹SELF›› pseudo targets.

Returns the permission updated with the ID of the current application

116.7.3 public abstract class ApplicationDescriptor

An OSGi service that represents an installed application and stores information about it. The application descriptor can be used for instance creation.

116.7.3.1 public static final String APPLICATION_CONTAINER = “application.container”

The property key for the application container of the application.

116.7.3.2 public static final String APPLICATION_COPYRIGHT = “application.copyright”

The property key for the localized copyright notice of the application.

116.7.3.3 **public static final String APPLICATION_DESCRIPTION = “application.description”**

The property key for the localized description of the application.

116.7.3.4 **public static final String APPLICATION_DOCUMENTATION = “application.documentation”**

The property key for the localized documentation of the application.

116.7.3.5 **public static final String APPLICATION_ICON = “application.icon”**

The property key for the localized icon of the application.

116.7.3.6 **public static final String APPLICATION_LAUNCHABLE = “application.launchable”**

The property key for the launchable property of the application.

116.7.3.7 **public static final String APPLICATION_LICENSE = “application.license”**

The property key for the localized license of the application.

116.7.3.8 **public static final String APPLICATION_LOCATION = “application.location”**

The property key for the location of the application.

116.7.3.9 **public static final String APPLICATION_LOCKED = “application.locked”**

The property key for the locked property of the application.

116.7.3.10 **public static final String APPLICATION_NAME = “application.name”**

The property key for the localized name of the application.

116.7.3.11 **public static final String APPLICATION_PID = “service.pid”**

The property key for the unique identifier (PID) of the application.

116.7.3.12 **public static final String APPLICATION_VENDOR = “service.vendor”**

The property key for the name of the application vendor.

116.7.3.13 **public static final String APPLICATION_VERSION = “application.version”**

The property key for the version of the application.

116.7.3.14 **public static final String APPLICATION_VISIBLE = “application.visible”**

The property key for the visibility property of the application.

116.7.3.15 **protected ApplicationDescriptor(String applicationId)**

applicationId The identifier of the application. Its value is also available as the service.pid service property of this ApplicationDescriptor service. This parameter must not be null.

□ Constructs the ApplicationDescriptor.

Throws `NullPointerException` – if the specified applicationId is null.

116.7.3.16 public final String getApplicationId( )

- Returns the identifier of the represented application.

Returns the identifier of the represented application

116.7.3.17 public final Map getProperties(String locale)

locale the locale string, it may be null, the value null means the default locale. If the provided locale is the empty String (“”)then raw (non-localized) values are returned.

- Returns the properties of the application descriptor as key-value pairs. The return value contains the locale aware and unaware properties as well. The returned Map will include the service properties of this ApplicationDescriptor as well.

  This method will call the getPropertiesSpecific method to enable the container implementation to insert application model and/or container implementation specific properties.

  The returned java.util.Map will contain the standard OSGi service properties as well (e.g. service.id, service.vendor etc.) and specialized application descriptors may offer further service properties. The returned Map contains a snapshot of the properties. It will not reflect further changes in the property values nor will the update of the Map change the corresponding service property.

Returns copy of the service properties of this application descriptor service, according to the specified locale. If locale is null then the default locale’s properties will be returned. (Since service properties are always exist it cannot return null.)

Throws IllegalStateException – if the application descriptor is unregistered

116.7.3.18 protected abstract Map getPropertiesSpecific(String locale)

locale the locale to be used for localizing the properties. If null the default locale should be used. If it is the empty String (“”) then raw (non-localized) values should be returned.

- Container implementations can provide application model specific and/or container implementation specific properties via this method. Localizable properties must be returned localized if the provided locale argument is not the empty String. The value null indicates to use the default locale, for other values the specified locale should be used. The returned java.util.Map must contain the standard OSGi service properties as well (e.g. service.id, service.vendor etc.) and specialized application descriptors may offer further service properties. The returned Map contains a snapshot of the properties. It will not reflect further changes in the property values nor will the update of the Map change the corresponding service property.

Returns the application model specific and/or container implementation specific properties of this application descriptor.

Throws IllegalStateException – if the application descriptor is unregistered

116.7.3.19 protected abstract boolean isLaunchableSpecific( )

- This method is called by launch() to verify that according to the container, the application is launchable.

Returns true, if the application is launchable according to the container, false otherwise.

Throws `IllegalStateException` – if the application descriptor is unregistered

116.7.3.20 public final ApplicationHandle launch(Map arguments) throws ApplicationException

arguments Arguments for the newly launched application, may be null

□ Launches a new instance of an application. The args parameter specifies the startup parameters for the instance to be launched, it may be null.

The following steps are made:

- Check for the appropriate permission.
- Check the locking state of the application. If locked then return null otherwise continue.
- Calls the launchSpecific() method to create and start an application instance.
- Returns the ApplicationHandle returned by the launchSpecific()

The Map argument of the launch method contains startup arguments for the application. The keys used in the Map must be non-null, non-empty String objects. They can be standard or application specific. OSGi defines the org.osgi.triggeringevent key to be used to pass the triggering event to a scheduled application, however in the future it is possible that other well-known keys will be defined. To avoid unwanted clashes of keys, the following rules should be applied:

- The keys starting with the dash (-) character are application specific, no well-known meaning should be associated with them.
- Well-known keys should follow the reverse domain name based naming. In particular, the keys standardized in OSGi should start with org.osgi..

The method is synchonous, it return only when the application instance was successfully started or the attempt to start it failed.

This method never returns null. If launching an application fails, the appropriate exception is thrown.

Returns the registered ApplicationHandle, which represents the newly launched application instance. Never returns null.

Throws `SecurityException` – if the caller doesn't have "lifecycle" ApplicationAdminPermission for the application.

`ApplicationException` – if starting the application failed

`IllegalStateException` – if the application descriptor is unregistered

`IllegalArgumentException` – if the specified Map contains invalid keys (null objects, empty String or a key that is not String)

116.7.3.21 protected abstract ApplicationHandle launchSpecific(Map arguments) throws Exception

arguments the startup parameters of the new application instance, may be null

- Called by launch() to create and start a new instance in an application model specific way. It also creates and registeres the application handle to represent the newly created and started instance and registeres it. The method is synchonous, it return only when the application instance was successfully started or the attempt to start it failed.

  This method must not return null. If launching the application failed, and exception must be thrown.

Returns the registered application model specific application handle for the newly created and started instance.

Throws `IllegalStateException` – if the application descriptor is unregistered

`Exception` – if any problem occures.

116.7.3.22 public final void lock( )

- Sets the lock state of the application. If an application is locked then launching a new instance is not possible. It does not affect the already launched instances.

Throws `SecurityException` – if the caller doesn't have "lock" ApplicationAdminPermission for the application.

`IllegalStateException` – if the application descriptor is unregistered

116.7.3.23 protected abstract void lockSpecific( )

- This method is used to notify the container implementation that the corresponding application has been locked and it should update the application.locked service property accordingly.

Throws `IllegalStateException` – if the application descriptor is unregistered

116.7.3.24 public abstract boolean matchDNChain(String pattern)

pattern a pattern for a chain of Distinguished Names. It must not be null.

- This method verifies whether the specified pattern matches the Distinguished Names of any of the certificate chains used to authenticate this application.

  The pattern must adhere to the syntax defined in org.osgi.service.application.ApplicationAdminPermission[p.289] for signer attributes.

  This method is used by `ApplicationAdminPermission.implies(java.security.Permission)`[p.291] method to match target ApplicationDescriptor and filter.

Returns true if the specified pattern matches at least one of the certificate chains used to authenticate this application

Throws `NullPointerException` – if the specified pattern is null.

`IllegalStateException` – if the application descriptor was unregistered

116.7.3.25 public final ScheduledApplication schedule(String scheduleId, Map arguments, String topic, String eventFilter, boolean recurring) throws InvalidSyntaxException, ApplicationException

scheduleId the identifier of the created schedule. It can be null, in this case the identifier is automatically generated.

arguments the startup arguments for the scheduled application, may be null

topic specifies the topic of the triggering event, it may contain a trailing asterisk as wildcard, the empty string is treated as "*", must not be null

eventFilter specifies and LDAP filter to filter on the properties of the triggering event, may be null

recurring if the recurring parameter is false then the application will be launched only once, when the event firstly occurs. If the parameter is true then scheduling will take place for every event occurrence; i.e. it is a recurring schedule

□ Schedules the application at a specified event. Schedule information should not get lost even if the framework or the device restarts so it should be stored in a persistent storage. The method registers a `ScheduledApplication`[p.300] service in Service Registry, representing the created schedule.

The Map argument of the method contains startup arguments for the application. The keys used in the Map must be non-null, non-empty String objects.

The created schedules have a unique identifier within the scope of this ApplicationDescriptor. This identifier can be specified in the scheduleId argument. If this argument is null, the identifier is automatically generated.

Returns the registered scheduled application service

Throws `NullPointerException` – if the topic is null

`InvalidSyntaxException` – if the specified eventFilter is not syntactically correct

`ApplicationException` – if the schedule couldn't be created. The possible error codes are ApplicationException.APPLICATION_DUPLICATE_SCHEDULE_ID if the specified scheduleId is already used for this ApplicationDescriptor ApplicationException.APPLICATION_SCHEDULING_FAILED if the scheduling failed due to some internal reason (e.g. persistent storage error).

`SecurityException` – if the caller doesn't have "schedule" ApplicationAdminPermission for the application.

`IllegalStateException` – if the application descriptor is unregistered

`IllegalArgumentException` – if the specified Map contains invalid keys (null objects, empty String or a key that is not String)

116.7.3.26 public final void unlock( )

□ Unsets the lock state of the application.

Throws `SecurityException` – if the caller doesn't have "lock" ApplicationAdminPermission for the application.

`IllegalStateException` – if the application descriptor is unregistered

116.7.3.27 protected abstract void unlockSpecific( )

□ This method is used to notify the container implementation that the corresponding application has been unlocked and it should update the application.locked service property accordingly.

Throws IllegalStateException – if the application descriptor is unregistered

116.7.4 public class ApplicationException extends Exception

This exception is used to indicate problems related to application lifecycle management. ApplicationException object is created by the Application Admin to denote an exception condition in the lifecycle of an application. ApplicationExceptions should not be created by developers. ApplicationExceptions are associated with an error code. This code describes the type of problem reported in this exception. The possible codes are:

- APPLICATION_LOCKED[p.297] - The application couldn't be launched because it is locked.
- APPLICATION_NOT_LAUNCHABLE[p.297] - The application is not in launchable state.
- APPLICATION_INTERNAL_ERROR[p.297] - An exception was thrown by the application or its container during launch.
- APPLICATION_SCHEDULING_FAILED[p.297] - The scheduling of an application failed.

116.7.4.1 public static final int APPLICATION_DUPLICATE_SCHEDULE_ID = 5

The application scheduling failed because the specified identifier is already in use.

116.7.4.2 public static final int APPLICATION_INTERNAL_ERROR = 3

An exception was thrown by the application or the corresponding container during launch. The exception is available in getCause()[p.298].

116.7.4.3 public static final int APPLICATION_LOCKED = 1

The application couldn't be launched because it is locked.

116.7.4.4 public static final int APPLICATION_NOT_LAUNCHABLE = 2

The application is not in launchable state, it's ApplicationDescriptor.APPLICATION_LAUNCHABLE[p.292] attribute is false.

116.7.4.5 public static final int APPLICATION_SCHEDULING_FAILED = 4

The application schedule could not be created due to some internal error (for example, the schedule information couldn't be saved).

116.7.4.6 public ApplicationException(int errorCode)

errorCode The code of the error

□ Creates an ApplicationException with the specified error code.

116.7.4.7 public ApplicationException(int errorCode, Throwable cause)

errorCode The code of the error

cause The cause of this exception.

- Creates a ApplicationException that wraps another exception.

116.7.4.8 public ApplicationException(int errorCode, String message)

errorCode The code of the error

message The associated message

- Creates an ApplicationException with the specified error code.

116.7.4.9 public ApplicationException(int errorCode, String message, Throwable cause)

errorCode The code of the error

message The associated message.

cause The cause of this exception.

- Creates a ApplicationException that wraps another exception.

116.7.4.10 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.

116.7.4.11 public int getErrorCode( )

- Returns the error code associcated with this exception.

Returns The error code of this exception.

116.7.5 public abstract class ApplicationHandle

ApplicationHandle is an OSGi service interface which represents an instance of an application. It provides the functionality to query and manipulate the lifecycle state of the represented application instance. It defines constants for the lifecycle states.

116.7.5.1 public static final String APPLICATION_DESCRIPTOR = “application.descriptor”

The property key for the pid of the corresponding application descriptor.

116.7.5.2 public static final String APPLICATION_PID = “service.pid”

The property key for the unique identifier (PID) of the application instance.

116.7.5.3 public static final String APPLICATION_STATE = “application.state”

The property key for the state of this appliction instance.

116.7.5.4 public static final String RUNNING = “RUNNING”

The application instance is running. This is the initial state of a newly created application instance.

116.7.5.5 public static final String STOPPING = “STOPPING”

The application instance is being stopped. This is the state of the application instance during the execution of the destroy() method.

116.7.5.6 protected ApplicationHandle(String instanceId, ApplicationDescriptor descriptor)

instanceId the instance identifier of the represented application instance. It must not be null.

descriptor the ApplicationDescriptor of the represented application instance. It must not be null.

- Application instance identifier is specified by the container when the instance is created. The instance identifier must remain static for the lifetime of the instance, it must remain the same even across framework restarts for the same application instance. This value must be the same as the service.pid service property of this application handle.

  The instance identifier should follow the following scheme: ‹*application descriptor PID*›.‹*index*› where ‹*application descriptor PID*› is the PID of the corresponding ApplicationDescriptor and ‹*index*› is a unique integer index assigned by the application container. Even after destroying the application index the same index value should not be reused in a reasonably long timeframe.

Throws `NullPointerException` – if any of the arguments is null.

116.7.5.7 public final void destroy( )

- The application instance's lifecycle state can be influenced by this method. It lets the application instance perform operations to stop the application safely, e.g. saving its state to a permanent storage.

  The method must check if the lifecycle transition is valid; a STOPPING application cannot be stopped. If it is invalid then the method must exit. Otherwise the lifecycle state of the application instance must be set to STOPPING. Then the destroySpecific() method must be called to perform any application model specific steps for safe stopping of the represented application instance.

  At the end the ApplicationHandle must be unregistered. This method should free all the resources related to this ApplicationHandle.

  When this method is completed the application instance has already made its operations for safe stopping, the ApplicationHandle has been unregistered and its related resources has been freed. Further calls on this application should not be made because they may have unexpected results.

Throws `SecurityException` – if the caller doesn't have "lifecycle" ApplicationAdminPermission for the corresponding application.

`IllegalStateException` – if the application handle is unregistered

116.7.5.8 protected abstract void destroySpecific( )

- Called by the destroy() method to perform application model specific steps to stop and destroy an application instance safely.

Throws `IllegalStateException` – if the application handle is unregistered

116.7.5.9 public final ApplicationDescriptor getApplicationDescriptor( )

- Retrieves the ApplicationDescriptor to which this ApplicationHandle belongs.

Returns The corresponding ApplicationDescriptor

116.7.5.10 public final String getInstanceId( )

- Returns the unique identifier of this instance. This value is also available as a service property of this application handle's service.pid.

Returns the unique identifier of the instance

116.7.5.11 public abstract String getState( )

- Get the state of the application instance.

Returns the state of the application.

Throws IllegalStateException – if the application handle is unregistered

116.7.6 public interface ScheduledApplication

It is allowed to schedule an application based on a specific event. ScheduledApplication service keeps the schedule information. When the specified event is fired a new instance must be launched. Note that launching operation may fail because e.g. the application is locked.

Each ScheduledApplication instance has an identifier which is unique within the scope of the application being scheduled.

ScheduledApplication instances are registered as services. The APPLICATION_PID[p.300] service property contains the PID of the application being scheduled, the SCHEDULE_ID[p.300] service property contains the schedule identifier.

116.7.6.1 public static final String APPLICATION_PID = "service.pid"

The property key for the identifier of the application being scheduled.

116.7.6.2 public static final String DAY_OF_MONTH = "day_of_month"

The name of the *day of month* attribute of a virtual timer event. The value is defined by java.util.Calendar.DAY_OF_MONTH.

116.7.6.3 public static final String DAY_OF_WEEK = "day_of_week"

The name of the *day of week* attribute of a virtual timer event. The value is defined by java.util.Calendar.DAY_OF_WEEK.

116.7.6.4 public static final String HOUR_OF_DAY = "hour_of_day"

The name of the *hour of day* attribute of a virtual timer event. The value is defined by java.util.Calendar.HOUR_OF_DAY.

116.7.6.5 public static final String MINUTE = "minute"

The name of the *minute* attribute of a virtual timer event. The value is defined by java.util.Calendar.MINUTE.

116.7.6.6 public static final String MONTH = "month"

The name of the *month* attribute of a virtual timer event. The value is defined by java.util.Calendar.MONTH.

116.7.6.7 public static final String SCHEDULE_ID = "schedule.id"

The property key for the schedule identifier. The identifier is unique within the scope of the application being scheduled.

116.7.6.8 public static final String TIMER_TOPIC = "org/osgi/application/timer"

The topic name for the virtual timer topic. Time based schedules should be created using this topic.

116.7.6.9 public static final String TRIGGERING_EVENT = "org.osgi.triggeringevent"

The key for the startup argument used to pass the event object that triggered the schedule to launch the application instance. The event is passed in a java.security.GuardedObject protected by the corresponding org.osgi.service.event.TopicPermission.

116.7.6.10 public static final String YEAR = "year"

The name of the *year* attribute of a virtual timer event. The value is defined by java.util.Calendar.YEAR.

116.7.6.11 public ApplicationDescriptor getApplicationDescriptor( )

- Retrieves the ApplicationDescriptor which represents the application and necessary for launching.

Returns the application descriptor that represents the scheduled application

Throws `IllegalStateException` – if the scheduled application service is unregistered

116.7.6.12 public Map getArguments( )

- Queries the startup arguments specified when the application was scheduled. The method returns a copy of the arguments, it is not possible to modify the arguments after scheduling.

Returns the startup arguments of the scheduled application. It may be null if null argument was specified.

Throws `IllegalStateException` – if the scheduled application service is unregistered

116.7.6.13 public String getEventFilter( )

- Queries the event filter for the triggering event.

Returns the event filter for triggering event

Throws `IllegalStateException` – if the scheduled application service is unregistered

116.7.6.14 public String getScheduleId( )

- Returns the identifier of this schedule. The identifier is unique within the scope of the application that the schedule is related to.

Returns the identifier of this schedule

116.7.6.15 public String getTopic( )

- Queries the topic of the triggering event. The topic may contain a trailing asterisk as wildcard.

Returns the topic of the triggering event

Throws `IllegalStateException` – if the scheduled application service is unregistered

116.7.6.16 public boolean isRecurring( )

- Queries if the schedule is recurring.

Returns true if the schedule is recurring, otherwise returns false

Throws `IllegalStateException` – if the scheduled application service is unregistered

116.7.6.17 public void remove( )

- Cancels this schedule of the application.

Throws `SecurityException` – if the caller doesn't have "schedule" ApplicationAdminPermission for the scheduled application.

`IllegalStateException` – if the scheduled application service is unregistered

116.8 References

[1] *PNG Image Format*
http://www.libpng.org/pub/png/

117 DMT Admin Service Specification

Version 1.0

117.1 Introduction

This specification defines an API for managing a device using concepts from the OMA DM specifications. This API is has been designed to be useful with or without an OSGi service platform. The API is decomposed in the following packages/functionality:

- info.dmtree – Main package that provides access to the local Device Management Tree. Access is session based.
- info.dmtree.notification – The notification package provides the capability to send alerts to the management server.
- info.dmtree.registry – This package provides access to the services defined in this specification when there is no service registry available.
- info.dmtree.spi – Provides the capability to register subtree handlers in the Device Management Tree.
- info.dmtree.notification.spi – The API to provide the possibilitity to send alerts and notifications to management servers.
- info.dmtree.security – Security classes.

This specification defines a number of services. Normally in an OSGi specification a service is a well defined entity. However, this specification is also applicable to environments where no OSGi service registry is present. In this case, the specified services are available from the DmtServiceFactory class.

117.1.1 Entities

- *Device Management Tree* – The Device Management Tree (DMT) is the logical view of manageable aspects of an OSGi Environment, structured in a tree with named nodes.
- *Dmt Admin* – A service through which the DMT can be manipulated. It is used by *local managers* or by *protocol adapters* that initiate DMT operations. The Dmt Admin service forwards selected DMT operations to Data Plugins and execute operations to Exec Plugins; in certain cases the Dmt Admin service handles the operations itself. The Dmt Admin service is a singleton.
- *Dmt Session* – A session groups a set of operations with optional transactionality and locking. Dmt Session objects are created by the Dmt Admin service and are given to a plugin when they first join the session.
- *Local Manager* – A bundle which uses the Dmt Admin service directly to read or manipulate the DMT. Local Managers usually do not have a principal associated with the session.

- *Protocol Adapter* – A bundle that communicates with a management server external to the device and uses the Dmt Admin service to operate on the DMT.
- *Meta Node* – Information provided by the node implementation about a node for the purpose of performing validation and providing assistance to users when these values are edited.
- *Multi nodes* – Interior nodes that have a homogeneous set of children. All these children share the same meta node.
- *Plugin* – Services which take the responsibility over a given sub-tree of the DMT: Data Plugin services and Exec Plugin services. Plugins exclusively manage a particular sub-tree, though Exec and Data Plugins can overlap.
- *Data Plugin* – A Plugin that can create a Readable Data Session, Read Write Data Session, or Transactional Data Session that handle data operations on a sub-tree for a Dmt Session.
- *Exec Plugin* – A Plugin that can handle execute operations.
- *Readable Data Session* – A plugin session that can only read.
- *Read Write Data Session* – A plugin session that can read and write.
- *Transactional Data Session* – A plugin session that is transactional.
- *Principal* – Represents the identity of the optional initiator of a Dmt Session. When a session has a principal, the Dmt Admin must enforce ACLs and must ignore Dmt Permissions.
- *ACL* – An Access Control List is a set of principals that is associated with permitted operations.
- *Dmt Event* – Provides information about an event inside Dmt Admin.
- *Dmt Event Listener* – Listeners to Dmt Events. These listeners can be registered with a Dmt Admin service.
- *Dmt Service Factory* – Provide access to the Dmt Admin service and Notification Service.

Figure 117.1 Using Dmt Admin service, info.dmtree package

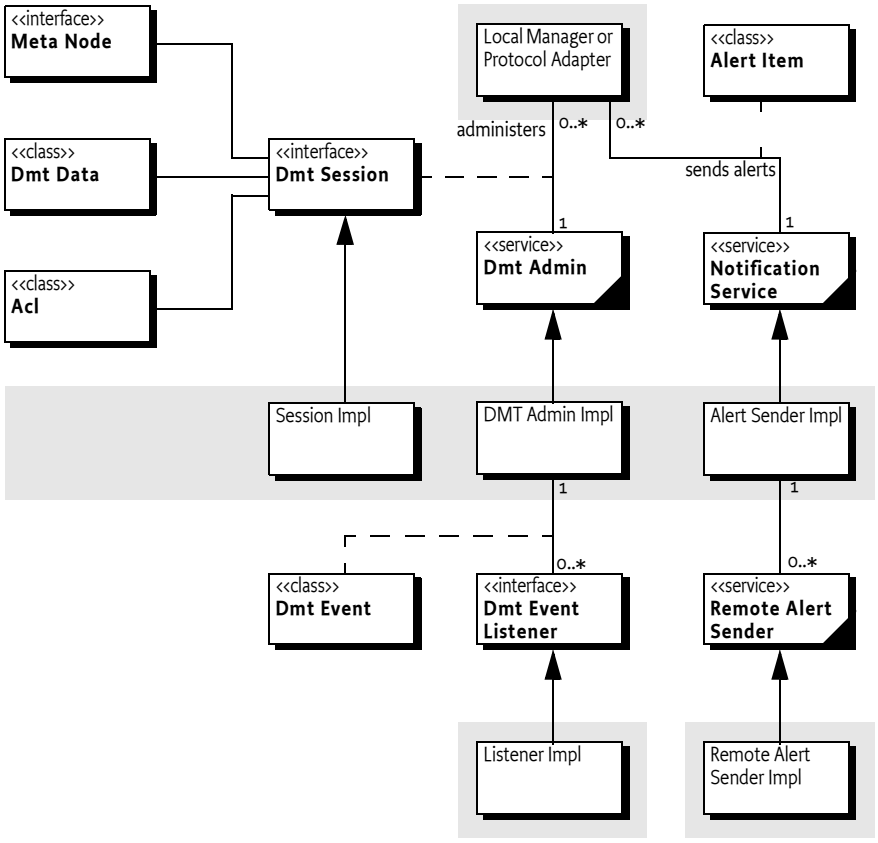
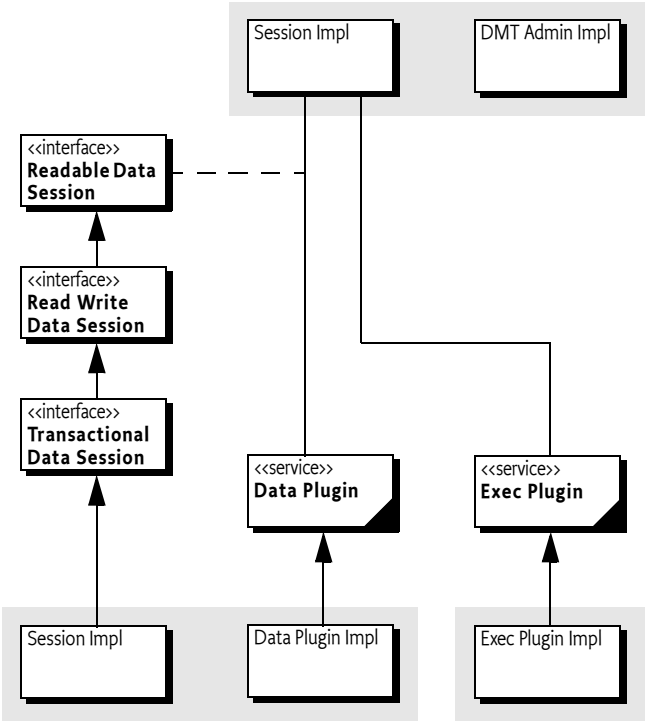
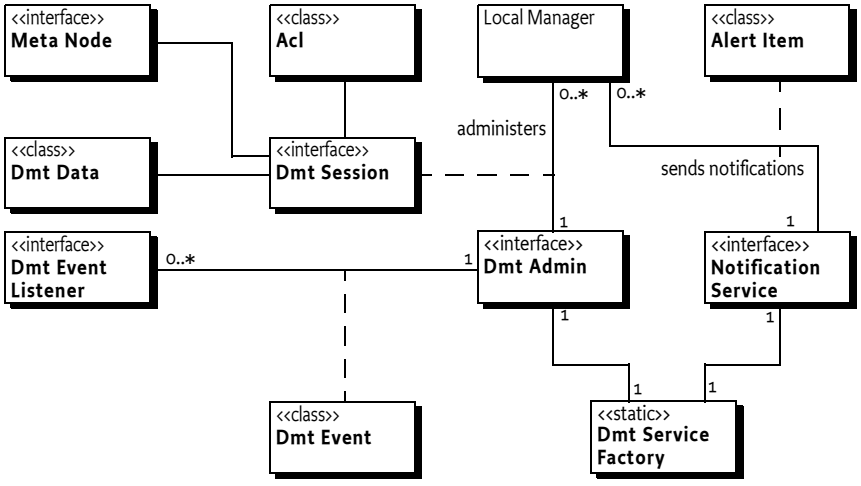


Figure 117.2 Extending the Dmt Admin service, info.dmtree.spi package



The bundle and service boundaries are not present when there is no Service Platform. In that case, the DmtServiceFactory class provides access to the Dmt Admin and Notification Service instances with a static method.

Figure 117.3 Dmt Admin service without Service Platform



117.2 The Device Management Model

The most important decision in determining any fundamentally new architecture is choosing a single meta-data model that expresses a common conceptual and semantic view for all consumers of that architecture. In the case of networked systems management, a number of meta-data models exist to choose from:

- *SNMP* – The best-established and most ubiquitous model for network management. See [7] *SNMP* for more information.
- JMX, a generic systems management model for Java, a de-facto standard in J2EE management. See [4] *Java™ Management Extensions Instrumentation and Agent Specification* for more information.
- *JSR 9 FMA* – Federated Management Architecture (FMA) [5], another Java standard originating in storage management. See [5] *JSR 9 - Federated Management Architecture (FMA) Specification.*
- *CIM/WBEM* – Common Information Model (CIM) and Web-Based Enterprise Management, a rich and extensible management meta-model developed by the DMTF. See [6] *WBEM Profile Template, DSP1000.*

For various reasons, none of these models enjoy any significant mind share within the mobile device community. Some, like SNMP, are primitive and very limited in functionality. Some, such as JMX and FMA, are too Java-centric and not well-suited for mobile devices.

One model that appears to have gained an almost universal acceptance is the Device Management Tree (DMT), introduced in support of the OMA DM protocol (formerly known as SyncML DM); see [1] *OMA DM-TND v1.2 draft.*

OMA DM provides a hierarchical model, like SNMP, but it is more sophisticated in the kinds of operations and data structures it can support.

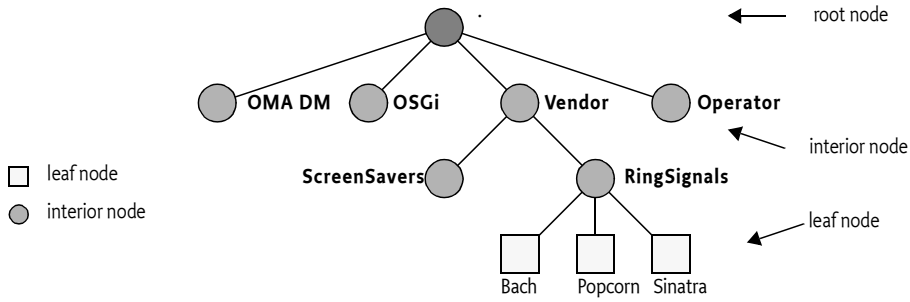
117.2.1 The Device Management Tree

The standard-based features of the DMT model are:

- The Device Management Tree consists of interior nodes and leaf nodes. Interior nodes can have children and leaf nodes have primitive values.
- All nodes have a set of properties: Name, Title, Format, ACL, Version, Size, Type, Value, and TimeStamp.
- The storage of the nodes is undefined. Nodes typically map to peripheral registers, settings, configuration, databases, etc.
- A node's name must be unique within its parent.
- Nodes can have Access Control Lists (ACLs), associating operations allowed on those nodes with a particular principal.
- Nodes can have Meta nodes that describe nodes and their siblings.
- Base value types (called *formats* in the standard) are
  - Integer
  - Unicode string
  - Boolean
  - Binary data
  - Date
  - Time
  - Float
  - XML fragments

- Leaf nodes in the tree can have default values specified in the meta node.
- Meta nodes have allowed access operations defined (`Get`, `Add`, `Replace`, `Delete` and `Exec`)

Figure 117.4 Device Management Tree example



Based on its industry acceptance and technical features, the *DMT model* was chosen as the uniform meta-data and operational model. In this capacity it is considered separately and independently from OMA DM or any other provisioning protocol. The DMT *model*, not the protocol, underlies all local and remote device management operations on the OSGi Environment.

Users of this specification should be familiar with the concept of the Device Management Tree and its properties and operations as defined by OMA DM; see [1] *OMA DM-TND v1.2 draft*.

117.2.2 Extensions

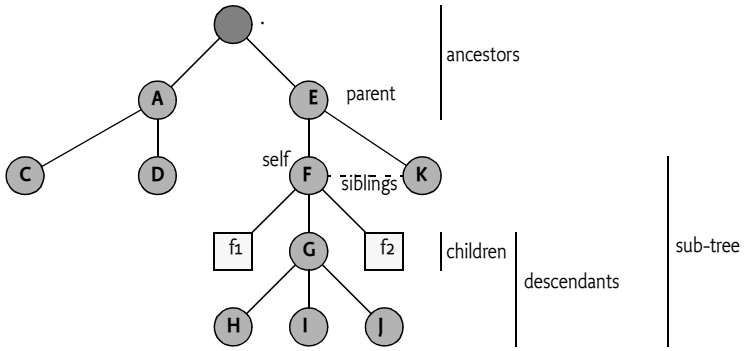
This specification introduces attributes in the meta nodes, refining semantics of both interior and leaf nodes. The following constraint information has been added to the meta data:

- *Range* – Max/min. values for numbers.
- *Enumeration* – Valid values for the node value as well as the node name.
- *Validation* – Provides a basis for determining whether a node name or value is valid.
- *Raw Format* – Support for future and non-standardized data formats.

117.2.3 Tree Terminology

In the following sections, the DMT is discussed frequently. Thus, well-defined terms for all the concepts that the DMT introduces are needed. The different terms are shown in Figure 117.5.

Figure 117.5 DMT naming, relative to node F



All terms are defined relative to node F. For this node, the terminology is as follows:

- *ancestors* – All nodes that are above the given node ordered in proximity. The closest node must be first in the list. In the example, this list is [./E, .]
- *parent* – The first ancestor, in this example this is ./E.
- *children* – A list of nodes that are directly beneath the given node without any preferred ordering. For node F this list is { ./E/F/f1, ./E/F/f2, ./E/F/G }.
- *siblings* – An unordered list of nodes that have the same parent. All siblings must have different names. For F, this is { ./E/K}
- *descendants* – A list of all nodes below the given node. For F this is { ./E/F/f1, ./E/F/G, ./E/F/f2, ./E/F/G/H, ./E/F/G/I, ./E/F/G/J }
- *sub-tree* – The given node plus the list of all descendants. For node F this is { ./E/F, ./E/F/f1, ./E/F/G, ./E/F/f2, ./E/F/G/H, ./E/F/G/I, ./E/F/G/J }
- *overlap* – Two given URIs overlap if they share any node in their sub-trees. In the example, the sub-tree ./E/F and ./E/F/G overlap.
- *Context Tree* – The context tree consists of the nodes that belong to the same logical unit as a given node. For example, the f1 node could describe an aspect of the J node. In that case, they both belong to the same context tree.

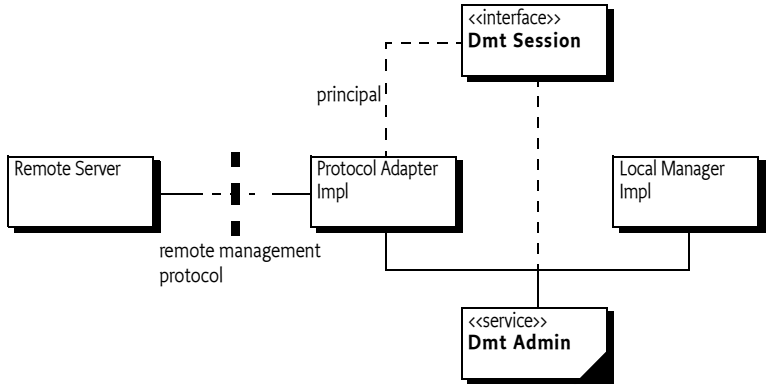
117.2.4 Actors

There are two typical users of the Dmt Admin service:

- *Remote manager* – The typical client of the Dmt Admin service is a *Protocol Adapter*. A management server external to the device can issue DMT operations over some management protocol. The protocol to be used is not specified by this specification; for example, OMA DM, OMA CP, and IOTA could be used. The protocol operations reach the service platform through the protocol adapter, which forwards the calls to the Dmt Admin service in a session. Protocol Adapters should authenticate the remote manager and set the principal in the session. This association will make the Dmt Admin enforce the ACLs. This requires that the principal is equal to the server name.
  The Dmt Admin provides a facility to send notifications to the remote manager with the Notification Service.

- *Local Manager* – A bundle which uses the Dmt Admin service to operate on the DMT: for example, a GUI application that allows the end user to change settings through the DMT.
  Although it is possible to manage some aspects of the system through the DMT, it can be easier for such applications to directly use the services that underlie the DMT; many of the management features available through the DMT are also available as services. These services shield the callers from the underlying details of the abstract, and sometimes hard to use DMT structure. As an example, it is more straightforward to use the Monitor Admin service than to operate upon the monitoring sub-tree. The local management application might listen to Dmt Events if it is interested in updates in the tree made by other entities, however, these events do not necessarily reflect the state of the underlying services.

Figure 117.6 Actors



117.3 The DMT Admin Service

The Dmt Admin service operates on the Device Management Tree of an OSGi-based device. The Dmt Admin API is closely modelled after the OMA DM protocol: the operations for `Get`, `Replace`, `Add`, `Delete` and `Exec` are directly available. The Dmt Admin is a singleton service.

Access to the DMT is session-based to allow for locking and transactionality. The sessions are, in principle, concurrent, but implementations that queue sessions can be compliant. The client indicates to the Dmt Admin service what kind of session is needed:

- *Exclusive Update Session*– Two or more updating sessions cannot access the same part of the tree simultaneously. An updating session must acquire an exclusive lock on the sub-tree which blocks the creation of other sessions that want to operate on an overlapping sub-tree.
- *Multiple Readers Session* – Any number of read-only sessions can run concurrently, but ongoing read-only sessions must block the creation of an updating session on an overlapping sub-tree.
- *Atomic Session* – An atomic session is the same as an exclusive update session, except that the session can be rolled back at any moment, undoing all changes made so far in the session. The participants must

accept the outcome: rollback or commit. There is no prepare phase. This specification does not mandate the support of atomic sessions. The lack of real transaction support can lead to error situations which are described later in this document; see *Plugins and Transactions* on page 327.

Although the DMT represents a persistent data store with transactional access and without size limitations, the notion of the DMT should not be confused with a general purpose database.

The intended purpose of the DMT is to provide a *dynamic view* of the management state of the device; the DMT model and the Dmt Admin service are designed for this purpose. Other kinds of usage, like storing and sharing generic application-specific data, are strictly discouraged because they can have severe performance implications.

117.4 Manipulating the DMT

117.4.1 The DMT Addressing URI

The OMA DM limits URIs to the definition of a URI in [8] *RFC 2396 Uniform Resource Identifiers (URI): Generic Syntax*. The Uri utility classes handles nearly all escaping issues with a number of static methods. All URIs in any of the API methods can use the full Unicode character set. For example, the following URIs as used in Java code are valid URIs for the Dmt Admin service.

```
"./ACME © 2000/A/x"
"./ACME/Address/Street/9C, Avenue St. Drézéry"
```

This strategy has a number of consequences.

- A slash ('/' \u002F) collides with the use of the slash as separator of the node names. Slashes must therefore be escaped using a backslash slash ('\/'). The backslash must be escaped with a double backslash sequence. Dmt Admin service must ignore a backslash when it is not followed by a slash or backslash. The slash and backslash must not be escaped using the %oo escaping. For example, a node that has the name of a MIME type could look like:

  ```
  ./OSGi/mime/application\/png
  ```

  In Java, a backslash must be escaped as well, therefore requiring double backslashes:

  ```
  String a = "./OSGi/mime/application\\/png";
  ```

- The length of a node name is defined to be the length of the byte array that results from UTF-8 encoding a string. This definition assumes that implementations store each character in the encoded URI as a single byte.
- Using the full Unicode character set for node names is discouraged because the encoding in the underlying storage—as well as the encoding needed in communications—can create significant performance and

memory usage overhead. Names that are restricted to the URI set [-a-zA-Z0-9_.!~*'()] are most efficient.

Dmt Admin service implementations usually have a limit on node length. This length can be found out with the getMaxSegmentNameLength() method. If a node name (not a URI, but only the name part of a node) is too long, the Dmt Admin service must throw an Exception. Clients of the Dmt Admin service can use the mangle(String) method; this method is described in *Node Name Mangling* on page 319. This method also handles any necessary escaping. Names are not automatically mangled, because a mangled name cannot be distinguished from a non-mangled name.

Nodes are addressed by presenting a *relative* or *absolute URI* for the requested node. Absolute URIs start with dot ('.' \u002E), if a URI starts with something else it is a relative URI. The Uri isAbsoluteUri(String) method makes it simple to find out if a URI is relative or absolute. Relative URIs require a base URI that is for example provided by the session, see *Locking and Sessions* on page 312.

Each node name is appended to the previous ones using a slash ('/' \u002F) as the separating character. The first node of an absolute URI must be the dot ('.'\u002E).

For example, to access the Bach leaf node in the RingTones interior node from Figure 117.4 on page 308, the URI must be:

```
./Vendor/RingSignals/Bach
```

The URI must be given with the root of the management tree as the starting point. URIs used in the DMT must be treated and interpreted as *case-sensitive*. I.e. ./Vendor and ./vendor designate two different nodes. The following mandatory restrictions on URI syntax are intended to simplify the parsing of URIs.

- *No End Slash* – A URI must not end with the delimiter slash ('/' \u002F). The root node must be denoted as . and not ./.
- *Parents* – A URI must not be constructed using the character sequence ../ to traverse the tree upwards.
- *Single Root* – The character sequence ./ must not be used anywhere other than in the beginning of a URI.
- *Max number of segments* – A URI can have a maximum number of segments. This maximum can be found out with the getMaxUriSegments() method.
- *Maximum length* – A URI is restricted in its total length. The maximum length can be discovered with the getMaxUriLength() method.

The isValidUri(String) method verifies that a URI fulfills all its obligations and is valid.

117.4.2 Locking and Sessions

The Dmt Admin service is the main entry point into the Device Management API, its usage is to create sessions.

A simple example is getting a session on a specific sub-tree. Such a session can be created with the getSession(String) method. This method creates an updating session with an exclusive lock on the given sub-tree. The given sub-tree can be a single leaf node if so desired.

Each session has an ID associated with it which is unique to the machine and is never reused. The URI argument addresses the sub-tree root. If null, it addresses the root of the DMT. All nodes can be reached from the root, so specifying a session root node is not strictly necessary but it permits certain optimizations in the implementation.

If the default exclusive locking mode of a session is not adequate, it is possible to specify the locking mode with the getSession(String,int) and getSession(String,String,int) method. These methods supports the following locking modes:

- LOCK_TYPE_SHARED – Creates a *shared session*. It is limited to read-only access to the given sub-tree, which means that multiple sessions are allowed to read the given sub-tree at the same time.
- LOCK_TYPE_EXCLUSIVE – Creates an *exclusive session*. The lock guarantees full read-write access to the tree. Such sessions, however, cannot share their sub-tree with any other session. This type of lock requires that the underlying implementation supports Read Write Data Sessions.
- LOCK_TYPE_ATOMIC – Creates an *atomic session* with an exclusive lock on the sub-tree, but with added transactionality. Operations on such a session must either succeed together or fail together. This type of lock requires that the underlying implementation supports Transactional Data Sessions.

The Dmt Admin service must lock the sub-tree in the requested mode before any operations are performed. If the requested sub-tree is not accessible, the getSession(String,int), getSession(String,int), or getSession(String) method must block until the sub-tree becomes available. The implementation can decide after an implementation-dependent period to throw a Dmt Exception with the SESSION_CREATION_TIMEOUT code.

As a simplification, the Dmt Admin service is allowed to lock the entire tree irrespective of the given sub-tree. For performance reasons, implementations should provide more fine-grained locking when possible.

Persisting the changes of a session works differently for exclusive and atomic sessions. Changes to the sub-tree in an atomic session are not persisted until the commit or close method of the session is called. Changes since the last transaction point can be rolled back with the rollback method.

The commit and rollback methods can be called multiple times in a session; they do not close the session. The open, commit, and rollback methods all establish a *transaction point*. The rollback operation cannot roll back further than the last transaction point.

Once a fatal error is encountered (as defined by the DmtException isFatal() method), all successful changes must be rolled back automatically. Non-fatal errors do not rollback the session. Any error/exception in the commit or rollback methods invalidates the session.

Changes in an exclusive session are persisted immediately after each operation. Errors do not roll back any changes made in such a session.

Due to locking and transactional behavior, a session of any type must be closed once it is no longer used. Locks must always be released, even if the close method throws an exception.

Once a session is closed no further operations are allowed and manipulation methods must throw an Illegal State Exception when called. Certain information methods like for example getState() and getRootUri() can still be called for logging or diagnostic purposes. This is documented with the Dmt Session methods.

The close or commit method can be expected to fail even if all or some of the individual operations were successful. This failure can occur due to multi-node constraints defined by a specific implementation. The details of how an implementation specifies such constraints is outside the scope of this specification.

Events in an atomic session must only be sent at commit time.

117.4.3 Associating a Principal

Protocol adapters must use the getSession(String,String,int) method which features the principal as the first parameter. The principal identifies the external entity on whose behalf the session is created. This server identification string is determined during the authentication process in a way specific to the management protocol.

For example, the identity of the OMA DM server can be established during the handshake between the OMA DM agent and the server. In the simpler case of OMA CP protocol, which is a one-way protocol based on WAP Push, the identity of the agent can be a fixed value.

117.4.4 Relative Addressing

All tree operation methods are found on the session object. Most of these methods accept a relative or absolute URI as their first parameter: for example, the method isLeafNode(String).

This URI is absolute or relative to the sub-tree with which the session is associated. For example, if the session is opened on:

```
./Vendor
```

then the following URIs address the Bach ring tone:

```
RingTones/Bach
./Vendor/RingTones/Bach
```

Opening the session with a null URI is identical to opening the session at the root. But the absolute URI can be used to address the Bach ring tone as well as a relative URI.

```
./Vendor/RingTones/Bach
Vendor/RingTones/Bach
```

If the URI specified does not correspond to a legitimate node in the tree, a Dmt Exception must be thrown. The only exception to this rule is the isNodeUri(String) method that can verify if a node is actually valid. The getMetaNode(String) method must accept URIs to non-existing nodes if an applicable meta node is available; otherwise it must also throw a Dmt Exception.

117.4.5 Creating Nodes

The methods that create interior nodes are:

- createInteriorNode(String) – Create a new interior node using the default meta data. If the principal does not have Replace access rights on the parent of the new node then the session must automatically set the ACL of the new node so that the creating server has Add, Delete and Replace rights on the new node.
- createInteriorNode(String,String) – Create a new interior node. The meta data for this new node is identified by the second argument, which is a URI *identifying* an OMA DM Device Description Framework (DDF) file, this does not have to be a valid location. It uses a format like org.osgi/1.0/LogManagementObject. This meta node must be consistent with any meta information from the parent node.
- createLeafNode(String) – Create a new leaf node with a default value.
- createLeafNode(String,DmtData) – Create a leaf node and assign a value to the leaf-node.
- createLeafNode(String,DmtData,String) – Create a leaf node and assign a value for the node. The last argument is the MIME type, which can be null.

For a node to be created, the following conditions must be fulfilled:

- The URI of the new node has to be a valid URI.
- The principal of the Dmt Session, if present, must have ACL Add permission to add the node to the parent. Otherwise, the caller must have the necessary permission.
- All constraints of the meta node must be verified, including value constraints, name constraints, type constraints, and MIME type constraints. If any of the constraints fail, a Dmt Exception must be thrown with an appropriate code.

117.4.6 Node Properties

A DMT node has a number of runtime properties that can be set through the session object. These properties are:

- *Title* – (String) A human readable title for the object. The title is distinct from the node name. The title can be set with setNodeTitle(String, String) and read with getNodeTitle(String). This specification does not define how this information is localized. This property is optional depending on the implementation that handles the node.
- *Type* –(String) The MIME type, as defined in [9] *MIME Media Types*, of the node's value.The type of an interior node is an URL identifying an OMA DM Device Description Framework file (DDF). The type can be set with setNodeType(String,String) and read with getNodeType(String).

- *Version* – (int) Version number, which must start at 0, incremented after every modification (for both a leaf and an interior node) modulo 0x10000. Changes to the value or any of the properties (including ACLs), or adding/deleting nodes, are considered changes. The getNodeVersion(String) method returns this version; the value is read-only. In certain cases, the underlying data structure does not support change notifications or makes it difficult to support versions. This property is optional depending on the node's implementation.
- *Size* – (int) The size is read-only and can be read with getNodeSize(String).
- *Time Stamp* –(Date) Time of the last change in version. The getNodeTimestamp(String) returns the time stamp. The value is read only. This property is optional depending on the node's implementation.
- *ACL* – The Access Control List for this and descendant nodes. The property can be set with setNodeAcl(String,Acl) and obtained with getNodeAcl(String).

If a plugin that does not implement an optional property is accessed, a Dmt Exception with the code FEATURE_NOT_SUPPORTED must be thrown.

117.4.7 Setting and Getting Data

Values are represented as DmtData objects, which are immutable. The are acquired with the getNodeValue(String) method and set with the setNodeValue(String[],info.dmtree.DmtData) method.

DmtData objectcs are dynamically typed by an integer enumeration. In OMA DM, this integer is called the *format* of the data value. The format of the DmtData class is similar to the type of a variable in a programming language, but the word *format* is used here to align it with the OMA DM specification.

Formats are defined with an integer enumeration:

- FORMAT_NULL–No valid data is available. DmtData objects with this format cannot be constructed; the only instance is the DmtData NULL_VALUE constant.
- FORMAT_BINARY– A byte array. The DmtData object is created with the DmtData(byte[]) constructor. The byte array can only be acquired with the getBinary() method.
- FORMAT_BOOLEAN– A boolean, it can only be acquired with the getBoolean() method. It can be created with the DmtData(boolean) constructor.
- FORMAT_INTEGER– An int. Only the getInt() method returns this value. It can be created with the DmtData(int) constructor.
- FORMAT_FLOAT– A float. Only the getFloat() method returns this value. It can be created with the DmtData(float) constructor.
- FORMAT_STRING– A String, can only be obtained with getString() and is constructed with the DmtData(String) method.
- FORMAT_TIME – A String object that is interpreted as an OMA time type. It can be set with the DmtData(String,int) method that takes the FORMAT_TIME as the second parameter.
- FORMAT_DATE – A String object that is interpreted as an OMA date type. It can be set with the DmtData(String,int) method that takes the FORMAT_DATE as the second parameter.

- FORMAT_XML – A string containing an XML fragment. It can be obtained with getXml(). The constructor is DmtData(String,int) with the int argument set to FORMAT_XML. The validity of the XML must not be verified by the Dmt Admin service.
- FORMAT_BASE64 – A byte[] that is formatted base 64. This format is created with the DmtData(byte[],boolean) method, where the boolean must be true. It can be obtained with getBase64().
- FORMAT_RAW_BINARY – A raw binary format is always created with a format name. This format name allows the creator to define a proprietary format. The constructor is DmtData(String,byte[]) and the value can be obtained with getRawBinary(). The format name is available from the getFormatName() method, which has predefined values for the standard formats.
- FORMAT_RAW_STRING – A raw string format is always created with a format name. This format name allows the creator to define a proprietary format. The constructor is DmtData(String,String) and the value can be obtained with getRawString(). The format name is available from the getFormatName() method, which has predefined values for the standard formats.
- FORMAT_NODE – A DmtData object can have a format of FORMAT_NODE. This value is returned from a MetaNode getFormat() method if the node is an interior node or for a data value when the Plugin supports complex values. This format is created with the DmtData(Object) constructor and can be obtained with the getNode() method.

The format of a DmtData object can be retrieved with the getFormat() and getFormatName(). The names for the standard formats are the OMA DM names. For example, the name for FORMAT_TIME must be time.

117.4.8 Complex Values

The OMA DM model prescribes that only leaf nodes have primitive values. This model maps very well to remote managers. However, when a manager is written in Java and uses the Dmt Admin API to access the tree, there are often unnecessary conversions from a complex object, to leaf nodes, and back to a complex object. For example, an interior node could hold the current GPS position as an OSGi Position object, which consists of a longitude, latitude, altitude, speed, and direction. All these objects are Measurement objects which consist of value, error, and unit. Reading such a Position object through its leaves only to make a new Position object is wasting resources. It is therefore that the Dmt Admin service also supports *complex values* as a supplementary facility.

If a complex value is used then the leaves must also be accessible and represent the same semantics as the complex value. A manager unaware of complex values must work correctly by only using the leaf nodes. Setting or getting the complex value of an interior node must be identical to setting or getting the leaf nodes.

Setting a complex value to an interior node must not change the structure of the tree. No new subnodes must be added, nor is it allowed to remove subnodes.

Accessing a complex value requires Get access to the node and all its decendants. Setting a complex value requires Replace access to the interior node.

Trying to set or get a complex value on an interior node that does not support complex values must throw a Dmt Exception with the code COMMAND_NOT_ALLOWED.

117.4.9 Nodes and MIME Types

The Dmt Admin service recognizes a MIME type for a node. This MIME type reflects how the data of the node should be *interpreted*. For example, it is possible to store a GIF and a JPEG image in a DmtData object with a FORMAT_BINARY format. Both the GIF and the JPEG object share the same *format*, but will have MIME types of image/jpg and image/gif respectively.

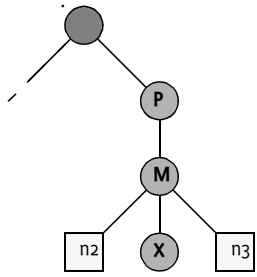
The node's MIME type can be set with the setNodeType(String,String) method and acquired with getNodeType(String).

117.4.10 Deleting Nodes

The deleteNode(String) method on the session represents the Delete operation. It deletes the sub-tree of that node. This method is applicable to both leaf and interior nodes. Nodes can be deleted by the Dmt Admin service in any order. The root node of the session can not be deleted.

For example, given Figure 117.7, deleting node P must delete the nodes ./P,./P/ M, ./P/M/X, ./P/M/n2 and ./P/M/n3 in any order.

Figure 117.7 DMT node and deletion



117.4.11 Copying Nodes

The copy(String,String,boolean) method on the DmtSession object represents the Copy operation. A node is completely copied to a new URI. It can be specified with a boolean if the whole sub-tree (true) or just the indicated node is copied.

The ACLs must not be copied; the new access rights must be the same as if the caller had created the new nodes individually. This restriction means that the copied nodes inherit the access rights from the parent of the destination node, unless the calling principal does not have Replace rights for the parent. See *Creating Nodes* on page 315 for details.

117.4.12 Renaming Nodes

The renameNode(String,String) method on the DmtSession object represents the Rename operation, which replaces the node name. It requires permission for the Replace operation. The root node for the current session can not be renamed.

117.4.13 Execute

The execute(String,String) and execute(String,String,String) methods can *execute* a node. Executing a node is intended to be used when a problem is hard to model as a set of leaf nodes. This can be related to synchronization issues or data manipulation. The execute methods can provide a correlator for a notification and an opaque string that is forwarded to the implementer of the node.

Execute operations can not take place in a read only session because simultaneous execution could make conflicting changes to the tree.

117.4.14 Closing

When all the changes have been made, the session must be closed by calling the close() method on the session. The Dmt Admin service must then finalize, clean up, and release any locks.

For atomic sessions, the Dmt Admin service must automatically commit any changes that were made since the last transaction point.

A session times out and is invalidated after an extended period of inactivity. The exact length of this period is not specified, but is recommended to be at least 1 minute and at most 24 hours. All methods of an invalidated session must throw an Invalid State Exception after the session is invalidated.

A session's state is one of the following: STATE_CLOSED, STATE_INVALID or STATE_OPEN, as can be queried by the getState() call. The invalid state is reached either after a fatal error case is encountered or after the session is timed out. When an atomic session is invalidated, it is automatically rolled back to the last transaction point of the session, at which the session had not yet been committed.

117.4.15 Node Name Mangling

Implementations of a Dmt Admin service can set a limit on the node name length. The node name length is defined as the length of the byte array of a UTF-8 encoded string. The node name length is a system-wide defined limit. For OMA DM, this limit can be found at the node ./DevDetail/URI/MaxSegLen. In this text this limit is called the *segment length*. As a convenience, these values are also available via static methods in the Uri class.

The Dmt Admin service must not accept long node names, and must throw a Dmt Exception with the code URI_TOO_LONG.

The user can prevent long names (and escaping issues) by mangling the name first with the mangle method on the Dmt Admin service. For example:

```
String uri = "./OSGi/Configuration/"
   + Uri.mangle( pid );
```

This method works as follows.

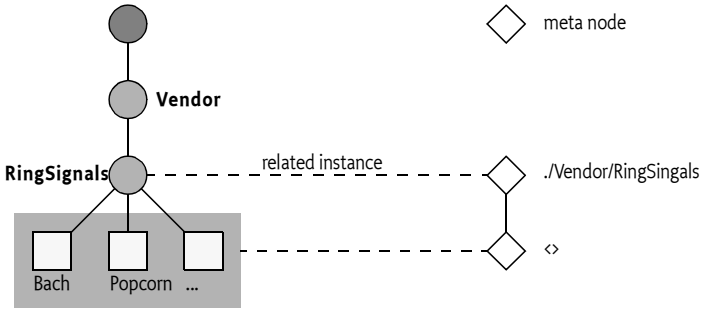
- A name with a node name length that is less or equal than the system defined limit only has to be escaped. Escaping is prefixing the slash ('/' \u002F) and back slash ('\' \u005C) characters with a backslash. Escaping does not influence the node name length, because this length is defined as the length of the unescaped UTF-8 encoded byte array.
- A longer name must be turned into a SHA 1 digest; see [11] *Secure Hash Algorithm 1*.
- This digest is then encoded with the base 64 algorithm; see [10] *RFC 3548 The Base16, Base32, and Base64 Data Encodings*.
- The encoded digest can now contain the slash ('/' \u002F). This character must be changed to an underscore ('_' \u005F).
- Any trailing equal signs ('=' \u003D) must be removed.

117.5 Meta Data

The getMetaNode(String) method returns a MetaNode object for a given URI. This node is called the *meta node*. A meta node provides information about nodes.

Any node can optionally have a meta node associated with it. The one or more nodes that are described by the meta nodes are called the meta node's *related instances*. A meta node can describe a singleton-related instance, or it can describe all the children of a given parent. That is to say, meta nodes can exist without an actual instance being present. For example, if a new ring tone, Grieg, was created in Figure 117.8 it would be possible to get the Meta Node for ./Vendor/RingSignals/Grieg before the node was created. This is usually the case for multi nodes. The model is depicted in Figure 117.8.

Figure 117.8 *Nodes and meta nodes*



A URI must always be associated with the same Meta Node. The getMetaNode(String) always returns the same meta node for the same URI.

The actual meta data can come from two sources:

- *Dmt Admin* – Each Dmt Admin likely has a private meta data repository. This meta data is placed in the device in a proprietary way.
- *Plugins* – Plugins can carry meta nodes and provide these to Dmt Admin by implementing the getMetaNode(String[]) method. If a plugin returns a non-null value, the Dmt Admin must use that value—possibly

complemented by its own metadata for elements not provided by the plugin.

The MetaNode interface supports methods to retrieve read-only meta data: both standard OMA DM as well as defined OSGi extensions and user extensions. The extensions were added to provide for better DMT data quality in an environment where many software components manipulate this data. These extensions do not break compatibility with OMA DM. Compatibility with OMA DM is further discussed in *Differences with OMA DM* on page 323.

117.5.1 Operations

The can(int) methods provide information as to whether the associated node can perform the given operation. This information is only about the capability; it can still be restricted in runtime by ACLs and permissions.

For example, if the can(MetaNode.CMD_EXECUTE) method returns true, the target object supports the Execute operation. That is, calling the execute(String,String) method with the target URI is possible.

The can(int) method can take the following constants as parameters:

- CMD_ADD
- CMD_DELETE
- CMD_EXECUTE
- CMD_GET
- CMD_REPLACE

For example:

```
void foo( DmtSession session, String nodeUri ) {
   MetaNode meta = session.getMetaNode(nodeUri);
  if ( meta !=null && meta.can(MetaNode.CMD_EXECUTE) )
      session.execute(nodeUri,"foo" );
}
```

117.5.2 Miscellaneous Meta Data

- getScope() – (int) Certain nodes represent structures in the devices that can never just be deleted or created; they represent an aspect of the device that cannot be controlled remotely. The scope defines whether the nodes can be created and deleted, or are permanent. Permanent nodes can, however, still appear and disappear. For example, an accessory that is plugged into the phone can create a new node. The return value of the getScope method describes this scope:
  - DYNAMIC – Nodes can be dynamically created and deleted.
  - PERMANENT – Nodes are permanent and cannot be created or deleted.
  - AUTOMATIC – A dynamic node that is created automatically, either when its parent node is created, or triggered by some other condition.

  For example, a node representing the battery level can never be deleted because it is an intrinsic part of the device; it will therefore be PERMANENT.
- getDescription() – (String) A description of the node. Descriptions can be used in dialogs with end users: for example, a GUI application that allows the user to set the value of a node. Localization of these values is not defined.

- getDefault() – (DmtData) A default data value.

117.5.3 Validation

The validation information allows the runtime system to verify constraints on the values; it also, however, allows user interfaces to provide guidance.

A node does not have to exist in the DMT in order to have meta data associated with it. Nodes may exist that have only partial meta data, or no metadata, associated with them. For each type of metadata, the default value to assume when it is omitted is described in *MetaNode* on page 391.

117.5.3.1 Data Types

A leaf node can be constrained to a certain format and one of a set of MIME types.

- getFormat() – (int) The required type. This type is a logical OR of the supported formats.
- getRawFormatNames() – Return an array of possible raw format names. This is only applicable when the getFormat() returns the FORMAT_RAW_BINARY or FORMAT_RAW_STRING formats. The method must return null otherwise.
- getMimeTypes() – (String[]) A list of MIME types. If this list is null, the DmtData value object can hold an arbitrary MIME type. Otherwise, the MIME type of the given DmtData object must be a member of the list returned from the getMimeTypes() method. The default value is the first entry.

117.5.3.2 Cardinality

A meta node can constrain the number of *siblings* (i.e., not the number of children) of an interior or leaf node. This constraint can be used to verify that a node must not be deleted, because there should be at least one node left on that level (isZeroOccurrenceAllowed()), or to verify that a node cannot be created, because there are already too many siblings (getMaxOccurrence()).

If the cardinality of a meta node is more than one, all siblings must share the same meta node to prevent an invalid situation. For example, if a node has two children that are described by different meta nodes, and any of the meta nodes has a cardinality >1, that situation is invalid.

For example, the ./Vendor/RingSignals/<> meta node (where <> stands for any name) could specify that there should be between 0 and 12 ring signals.

- getMaxOccurrence() – (int) A value greater than 0 that specifies the maximum number of instances for this node.
- isZeroOccurrenceAllowed() – (boolean) Returns true if zero instances are allowed. If not, the last instance must not be deleted.

117.5.3.3 Matching

The following methods provide validation capabilities for leaf nodes.

- isValidValue(DmtData) – (DmtData) Verify that the given value is valid for this meta node.

- getValidValues() – (DmtData[]) A set of possible values for a node, or null otherwise. This can for example be used to give a user a set of options to choose from.

117.5.3.4 Numeric Ranges

Numeric leaf nodes (format must be FORMAT_INTEGER or FORMAT_FLOAT) can be checked for a minimum and maximum value.

Minimum and maximum values are inclusive. That is, the range is [getMin(),getMax()]. For example, if the maximum value is 5 and the minimum value is -5, then the range is [-5,5]. This means that valid values are -5,-4,-3,-2... 4, 5.

- getMax() – (double) The value of the node must be less than or equal to this maximum value.
- getMin() – (double) The value of the node must be greater than or equal to this minimum value.

If no meta data is provided for the minimum and maximum values, the meta node must return the Double.MIN_VALUE, and Double.MAX_VALUE respectively.

117.5.3.5 Name Validation

The meta node provides the following name validation facilities for both leaf and interior nodes:

- isValidName(String) – (String) Verifies that the given name matches the rules for this meta node.
- getValidNames() – (String[]) An array of possible names. A valid name for this node must appear in this list.

117.5.4 User Extensions

The Meta Node provides an extension mechanism; each meta node can be associated with a number of properties. These properties are then interpreted in a proprietary way. The following methods are used for user extensions:

- getExtensionPropertyKeys() – Returns an array of key names that can be provided by this meta node.
- getExtensionProperty(String) – Returns the value of an extension property.

For example, a manufacturer could use a regular expression to validate the node names with the isValidName(String) method. In a web based user interface it is interesting to provide validity checking in the browser, however, in such a case the regular expression string is required. This string could then be provided as a user extension under the key x-acme-regex-javascript.

117.5.5 Differences with OMA DM

As the meta data of a node in OSGi provides more features than are mandated by OMA DM, the Dmt Admin nodes cannot be fully described by OMA DM's DDF (Device Description Framework). How the management server learns the OSGi management object structure is out of the scope of this specification.

The following table shows the differences between the OSGi meta data and the Data Description Framework of the OMA. The DTD description of DDF can be found at [1] *OMA DM-TND v1.2 draft*.

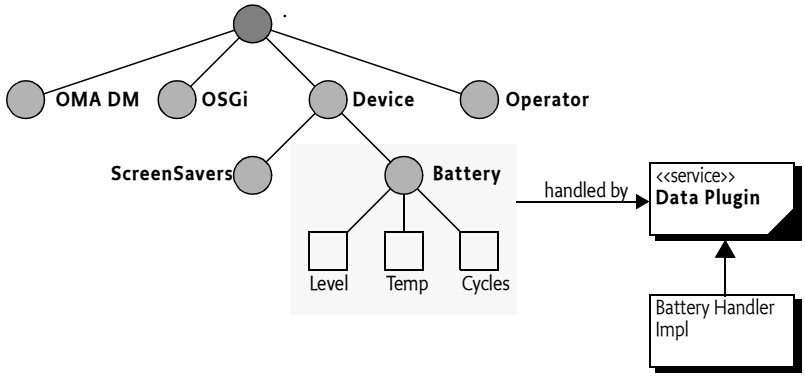
Table 117.1 Comparison of OMA DM DDF versus OSGi meta data

	DDF Fragment	Comment
can	AccessType: Add, Delete, Exec, Get, Replace	
	AccessType: Copy	Missing in OSGi
getScope	Scope: Permanent | Dynamic | Automatic	
getDefault	DefaultValue:	
getFormat	Single format allowed for leaf nodes	OSGi allows multiple formats
isLeaf		
getDescription	Description:	
getMaxOccurrences, isZeroOccurrencesAllowed	Occurrence: One | ZeroOrOne | ZeroOrMore | OneOrMore | ZeroOrN | OneOrN	
getMax, getMin		Missing in OMA
getMimeTypes	Type: MIME List or DDF document URI	OSGi does not allow specifying the DDF document URI; only MIME types are supported
getValidValues		Missing in OMA
getValidNames		Missing in OMA

117.6 Plugins

The Plugins take the responsibility of handling DMT operations within certain sub-trees of the DMT. It is the responsibility of the Dmt Admin service to forward the operation requests to the appropriate plugin. The only exceptions are the ACL manipulation commands. ACLs must be enforced by the Dmt Admin service: never by the plugin.

Figure 117.9 Device Management Tree example



Plugins are OSGi services. The Dmt Admin must dynamically add and remove the plugins, acting as node handler, as they are registered and unregistered. Service properties are used to specify the sub-tree that the plugin can manage. Overlapping plugins are explicitly not allowed. Therefore, it is not possible for a plugin to control the same, or part of the same, sub-tree that another plugins controls.

It is the responsibility of the Dmt Admin service to guard against the registration of plugins that attempt to manage an overlapping sub-tree. If more than one plugin of the same type (Data or Exec) is registered for a particular node, the Dmt Admin service must log an error and ignore the second registration. In other words, the plugin which registered itself first will get priority over other plugins that register later. Exec Plugins are allowed to overlap Data Plugins.

For example, a plugin related to Configuration Admin handles the sub-tree which stores configuration data. This sub-tree could start at `./OSGi/Configuration`. When the client wants to add a new configuration object to the DMT, it must issue an `Add` operation to the `./OSGi/Configuration` node. The Dmt Admin then forwards this operation to the configuration plugin. The plugin maps the request to one or more method calls on the Configuration Admin service. Such a plugin can be a simple proxy to the Configuration Admin service, so it can provide a DMT view of the configuration data store.

In other cases, plugin implementations may need a proprietary backdoor to the service they make available in the DMT. For instance, the Monitor Admin service provides only methods to start local monitoring jobs; there is no public method for creating a remotely initiated job.

There are two types of Dmt plugins: *data plugins* and *exec plugins*. A data plugin is responsible for handling the sub-tree retrieval, addition and deletion operations, and handling of meta data, while an exec plugin handles the node execution operation.

117.6.1 Data Sessions

Data Plugins must participate in the Dmt Admin sessions. A Data Plugin provider must therefore register a Data Plugin service. Such a service can create a session for the Dmt Admin service when the given sub-tree is accessed by a Dmt Session. If the associated Dmt Session is later closed, the Data Session will also be closed. Three types of sessions provide different capabilities. Data Plugins do not have to implement all session types; if they do not, they can return null.

- *Readable Data Session* – Must always be supported. It provides the basic read-only access to the nodes and the close method. The Dmt Admin service uses this session type when the lock mode is LOCK_TYPE_SHARED for the Dmt Session. Such a session is created with the plugin's openReadOnlySession(String[],info.dmtree.DmtSession), method which returns a ReadableDataSession object.
- *Read Write Data Session* – Extends the Readable Data Session with capabilities to modify the DMT. This is used for Dmt Sessions that are opened with LOCK_TYPE_EXCLUSIVE. Such a session is created with the plugin's openReadWriteSession(String[],info.dmtree.DmtSession) method, which returns a ReadWriteDataSession object.
- *Transactional Data Session* – Extends the Read Write Data Session with commit and rollback methods so that this session can be used with transactions. It is used when the Dmt Session is opened with lock mode LOCK_TYPE_ATOMIC. Such a session is created with the plugin's openAtomicSession(String[],info.dmtree.DmtSession) method, which returns a TransactionalDataSession object.

117.6.2 URIs and Plugins

The plugin Data Sessions do not use a simple string to identify a node, like the Dmt Session does. Instead the URI parameter is a String[]. The members of this String[] are the different segments. The first node after the root is the second segment and the node name is the last segment. The different segments require escaping of the slash and backslash ('/' and'\').

The reason to use String[] objects instead of the original string is to reduce the number times that the URI is parsed. The entry String objects, however, are still escaped (and potentially mangled). For example, the URI ./A/B/image\/jpg gives the following String[]:

```
{ ".", "A", "B", "image\/jpg" }
```

A plugin can assume that the path is validated and can be used directly.

117.6.3 Associating a sub-tree

Each plugin is associated with one ore more DMT sub-trees. The top node of a sub-tree is called the *plugin root*. The plugin root is defined by a service registration property. This property is different for exec plugins and data plugins:

- dataRootURIs – (String[], String) Must be used by data plugins.
- execRootURIs – (String[], String) Must be used by exec plugins.

The reason for the different properties is to allow a single service to register both as a Data Plugin service as well as an Exec Plugin service.

Only nodes having occurrence=1 in their meta data can be plugin roots. If a given type of node can occur in multiple instances with different names on the same level, a plugin cannot be rooted at any of these nodes.

For example, a data plugin can register itself in its activator to handle the sub-tree ./Dev/Battery:

```
public void start(BundleContext context) {
  Hashtable ht = new Hashtable();
  ht.put(Constants.SERVICE_PID, "com.acme.data.plugin");
  ht.put( "dataRootURIs", "./Dev/Battery");
  context.registerService(
      DataPlugin.class.getName(),
      new BatteryHandler(context);
      ht );
}
```

If this activator was executed, an access to ./Dev/Battery must be forwarded by the Dmt Admin service to this plugin via a data session.

117.6.4 Synchronization with Dmt Admin Service

The Dmt Admin service can, in certain cases, detect that a node was changed without the plugin knowing about this change. For example, if the ACL is changed, the version and timestamp must be updated; these properties are maintained by the plugin. In these cases, the Dmt Admin service must open a ReadableDataSession and call nodeChanged(String[]) method with the changed URI.

117.6.5 Plugin Meta Data

Plugins can provide meta data; meta data from the Plugin must take precedence over the meta data of the Dmt Admin service.

If a plugin provides meta information, the Dmt Admin service must verify that an operation is compatible with the meta data of the given node.

For example if the plugin reports in its meta data that the ./A leaf node can only have the text/plain MIME type, the createLeafNode(String[], info.dmtree.DmtData,String) call must not be forwarded to the Plugin if the third argument specifies any other MIME type. If this contract between the Admin and the plugin is violated, the plugin should throw an Illegal State Exception.

117.6.6 Plugins and Transactions

For the Dmt Admin service to be transactional, transactions must be supported by the data plugins. This support is not mandatory in this specification, and therefore the Dmt Admin service has no transactional guarantees for atomicity, consistency, isolation or durability. The DmtAdmin interface and the DataPlugin (or more specifically the data session) interfaces, however, are designed to support Data Plugin services that are transactional. Exec plugins need not be transaction-aware because the execute method does not provide transactional semantics, although it can be executed in an atomic transaction.

Data Plugins do not have to support atomic sessions. When the Dmt Admin service creates a Transactional Data Session by calling openAtomicSession(String[],info.dmtree.DmtSession) the Data Plugin is allowed to return null. In that case, the plugin does not support atomic sessions. The caller receives a Dmt Exception with a TRANSACTION_ERROR code.

Plugins must persist any changes immediately for Read Write Data Sessions. Transactional Data Sessions must delay changes until the commit method is called, which can happen multiple times during a session. The open, commit, and rollback methods all establish a *transaction point*. Rollback can never go further back than the last transaction point.

- commit() – Commit any changes that were made to the DMT but not yet persisted. This method should not throw an Exception because other Plugins already could have persisted their data and can no longer roll it back. The commit method can be called multiple times in an open session, and if so, the commit must make persistent the changes since the last transaction point.
- rollback() – Undo any changes made to the sub-tree since the last transaction point.
- close() – Clean up and release any locks. The Dmt Admin service must call the commit methods before the close method is called. A Plugin must not perform any persistency operations in the close method.

The commit(), rollback(), and close() plugin data session methods must all be called in reverse order of that in which Plugins joined the session.

If a Plugin throws a fatal exception during an operation, the Dmt Session must be rolled back immediately, automatically rolling back all data plugins, as well as the plugins that threw the fatal Dmt Exception. The fatality of an Exception can be checked with the Dmt Exception isFatal() method.

If a plugin throws a non-fatal exception in any method accessing the DMT, the current operation fails, but the session remains open for further commands. All errors due to invalid parameters (e.g. non-existing nodes, unrecognized values), all temporary errors, etc. should fall into this category.

A rollback of the transaction can take place due to any irregularity during the session. For example:

- A necessary Plugin is unregistered
- A fatal exception is thrown while calling a plugin
- Critical data is not available
- An attempt is made to breach the security

Any Exception thrown during the course of a commit or rollback method call is considered fatal, because the session can be in a half-committed state and is not safe for further use. The operation in progress should be continued with the remaining Plugins to achieve a *best-effort* solution in this limited transactional model. Once all plugins have been committed or rolled back, the Dmt Admin service must throw an exception, specifying the cause exception(s) thrown by the plugin(s), and should log an error.

117.6.7 Side Effects

Changing a node's value will have a side effect of changing the system. A plugin can also, however, cause state changes with a get operation. Sometimes the pattern to use a get operation to perform a state changing action can be quite convenient. The get operation, however, is defined to have no side effects. This definition is reflected in the session model, which allows the DMT to be shared among readers. Therefore, plugins should refrain from causing side effects for read-only operations.

117.6.8 Copying

Plugins do not have to support the copy operation. They can throw a Dmt Exception with a code FEATURE_NOT_SUPPORTED. In this case, the Dmt Admin service must do the copying node by node. For the clients of the Dmt Admin service, it therefore appears that the copy method is always supported.

117.7 Access Control Lists

Each node in the DMT can be protected with an *access control list*, or *ACL*. An ACL is a list of associations between *Principal* and *Operation*:

- *Principal* – The identity that is authorized to use the associated operations. Special principal is the wildcard ('*' \u002A); the operations granted to this principal are called the *global permissions*. The global permissions are available to all principals.
- *Operation* – A list of operations: ADD, DELETE, GET, REPLACE, EXECUTE.

DMT ACLs are defined as strings with an internal syntax in [1] *OMA DM-TND v1.2 draft*. Instances of the ACL class can be created by supplying a valid OMA DM ACL string as its parameter. The syntax of the ACL is presented here in shortened form for convenience:

```
acl        ::= ( acl-entry ( '&' acl-entry )* )?
acl-entry  ::= command '=' ( principals | '*' )
principals ::=  principal ( '+' principal )*
principal  ::= [^=&*+ \t\n\r]+
```

The principal name should only use printable characters according to the OMA DM specification.

```
command    ::= 'Add' | 'Delete' | 'Exec' | 'Get' | 'Replace'
```

White space between tokens is not allowed.

Examples:

```
Add=*&Replace=*&Get=*

Add=www.sonera.fi-8765&Delete=www.sonera.fi-
8765&Replace=www.sonera.fi-8765+321_ibm.com&Get=*
```

The Acl(String) constructor can be used to construct an ACL from an ACL string. The toString() method returns a String object that is formatted in the specified form, also called the canonical form. In this form, the principals must be sorted alphabetically and the order of the commands is:

ADD, DELETE, EXEC, GET, REPLACE

The Acl class is immutable, meaning that a Acl object can be treated like a string, and that the object cannot be changed after it has been created.

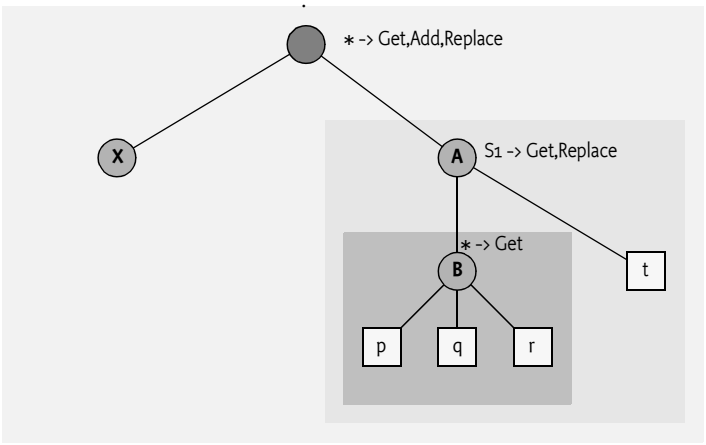
ACLs must only be verified by the Dmt Admin service when the session has an associated principal.

ACLs are properties of nodes. If an ACL is *not set* (i.e. contains no commands nor principals), the *effective* ACL of that node must be the ACL of its first ancestor that has a non-empty ACL. This effective ACL can be acquired with the getEffectiveNodeAcl(String) method. The root node of DMT must always have an ACL associated with it. If this ACL is not explicitly set, it should be set to Add=*&Get=*&Replace=*.

This effect is shown in Figure 117.10. This diagram shows the ACLs set on a node and their effect (which is shown by the shaded rectangles). Any principal can get the value of p, q and r, but they cannot replace, add or delete the node. Node t can only be read and replaced by principal S1.

Node X is fully accessible to any authenticated principal because the root node specifies that all principals have Get, Add and Replace access (*->G,A, R).

Figure 117.10 ACL inheritance



The definition and example demonstrate the access rights to the properties of a node, which includes the value.

Changing the ACL property itself has different rules. If a principal has Replace access to an interior node, the principal is permitted to change its own ACL property *and* the ACL properties of all its child nodes. Replace access on a leaf node does not allow changing the ACL property itself.

In the previous example, only principal S1 is authorized to change the ACL of node B because it has Replace permission on node B's parent node A.

Figure 117.11 ACLs for the ACL property

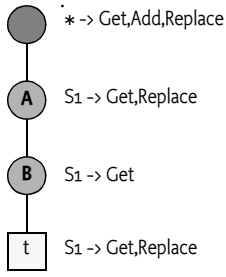


Figure 117.11 demonstrates the effect of this rule with an example. Server S1 can change the ACL properties of all interior nodes. A more detailed analysis:

- *Root* – The root allows all authenticated principals to access it. The root is an interior node so the Replace permission permits the change of the ACL property.
- *Node A* – Server S1 has Replace permission and node A is an interior node so principal S1 can modify the ACL.
- *Node B* – Server S1 has no Replace permission for node B, but the parent node A of node B grants principal S1 Replace permission, and S1 is therefore permitted to change the ACL.
- *Node t* – Server S1 must not be allowed to change the ACL of node t, despite the fact that it has Replace permission on node t. For leaf nodes, permission to change an ACL is defined by the Replace permission in the parent node's ACL. This parent, node B, has no such permission set and thus, access is denied.

The following methods provide access to the ACL property of the node.

- getNodeAcl(String) – Return the ACL for the given node, this method must not take any ACL inheritance into account. The ACL may be null if no ACL is set.
- getEffectiveNodeAcl(String) – Return the effective ACL for the given node, taking any inheritance into account.
- setNodeAcl(String,Acl) – Set the node's ACL. The ACL can be null, in which case the effective permission must be derived from an ancestor. The Dmt Admin service must call nodeChanged(String[]) on the data session with the given plugin to let the plugin update any timestamps and versions.

The Acl class maintains the permissions for a given principal in a bit mask. The following permission masks are defined as constants in the Acl class:

- ADD
- DELETE
- EXEC
- GET
- REPLACE

The class features methods for getting permissions for given principals. A number of methods allow an existing ACL to be modified while creating a new ACL.

- addPermission(String,int) – Return a new Acl object where the given permissions have been added to permissions of the given principal.
- deletePermission(String,int) – Return a new Acl object where the given permissions have been removed from the permissions of the given principal.
- setPermission(String,int) – Return a new Acl object where the permissions of the given principal are overwritten with the given permissions.

Information from a given ACL can be retrieved with:

- getPermissions(String) – (int) Return the combined permission mask for this principal.
- getPrincipals() – (String[]) Return a list of principals (String objects) that have been granted permissions for this node.

Additionally, the isPermitted(String,int) method verifies if the given ACL authorizes the given permission mask. The method returns true if all commands in the mask are allowed by the ACL.

For example:

```
Acl   acl = new Acl("Get=S1&Replace=S1");

if (  acl.isPermitted("S1", Acl.GET+Acl.REPLACE ))
   ... // will execute

if ( acl.isPermitted(
   "S1", Acl.GET+Acl.REPLACE+Acl.ADD ))
   ... // will NOT execute
```

117.7.1 Global Permissions

Global permissions are indicated with the '*' and the given permissions apply to all principals. Processing the global permissions, however, has a number of non-obvious side effects:

- Global permissions can be retrieved and manipulated using the special'*' principal: all methods of the Acl class that have a principal parameter also accept this principal.
- Global permissions are automatically granted to all specific principals. That is, the result of the getPermissions or isPermitted methods will be based on the OR of the global permissions and the principal-specific permissions.
- If a global permission is revoked, it is revoked from all specific principals, even if the specific principals already had that permission before it was made global.
- None of the global permissions can be revoked from a specific principal. The OMA DM ACL format does not handle exceptions, which must be enforced by the deletePermission and setPermission methods.

117.7.2 Ghost ACLs

The ACLs are fully maintained by the Dmt Admin service and enforced when the session has an associated principal. A plugin must be completely unaware of any ACLs. The Dmt Admin service must synchronize the ACLs with any change in the DMT that is made through its service interface. For example, if a node is deleted through the Dmt Admin service, it must also delete an associated ACL.

The DMT nodes, however, are mapped to plugins, and plugins can delete nodes outside the scope of the Dmt Admin service.

As an example, consider a configuration record which is mapped to a DMT node that has an ACL. If the configuration record is deleted using the Configuration Admin service, the data disappears, but the ACL entry in the Dmt Admin remains. If the configuration dictionary is recreated with the same PID, it will get the old ACL, which is likely not the intended behavior.

This specification does not specify a solution to solve this problem. Suggestions to solve this problem are:

- Use a proprietary callback mechanism from the underlying representation to notify the Dmt Admin service to clean up the related ACLs.
- Implement the services on top of the DMT. For example, the Configuration Admin service could use a plugin that provides general data storage service.

117.8 Notifications

In certain cases it is necessary for some code on the device to alert a remote management server or to initiate a session; this process is called sending a notification or an *alert*. Some examples:

- A Plugin that must send the result of an asynchronous `EXEC` operation.
- Sending a request to the server to start a management session.
- Notifying the server of completion of a software update operation.

Notifications can be sent to a management server using the `sendNotification(String,int,String,AlertItem[])` method on the Notification Service, which is available from the service registry or from the `DmtServiceFactory getNotificationService()`. This method is on the Notification Service and not on the session, because the session can already be closed when the need for an alert arises. If an alert is related to a session, the session can provide the required principal, even after it is closed.

The remote server is alerted with one or more `AlertItem` objects. The `AlertItem` class describes details of the alert. In OMA DM, sending an alert requires an *alert code*. Alert codes are defined by OMA DM and others. An alert code is a type identifier, usually requiring specifically formatted `AlertItem` objects.

The data syntax and semantics varies widely between various alerts, and so does the optionality of particular parameters of an alert item. If an item, such as source or type, is not defined, the corresponding getter method must return `null`.

The AlertItem class contains the following items. The value of these items must be defined in an alert definition:

- source – (String) The URI of a node that is related to this request. This parameter can be null.
- type – (String) The type of the item. For example, x-oma-application:syncml.samplealert in the Generic Alert example.
- mark – (String) Mark field of an alert. Contents depend on the alert type.
- data – (DmtData) The payload of the alert with its type.

An AlertItem object can be constructed with two different constructors:

- AlertItem(String,String,String,info.dmtree.DmtData) – This method takes all the previously defined fields.
- AlertItem(String[],String,String,info.dmtree.DmtData) – Same as previous but with a convenience parameter for a segmented URI.

The Notification Service provides the following method to send AlertItem objects to the management server:

- sendNotification(String,int,String,AlertItem[]) – Send the alert to the server that is associated with the session. The first argument is the name of the principal (identifying the remote management system) or null for implementation defined routing. The int argument is the *alert type*. The alert types are defined by *managed object types*. The third argument (String) can be used for the correlation id of a previous execute operation that triggered the alert. The AlertItem objects contain the data of the alert. The method will run asynchronously from the caller. The Notification Service must provide a reliable delivery method for these alerts. Alerts must therefore not be re-transmitted.
  When this method is called with null and 0 as values, it should send a protocol specific notification that must initiate a new management session.

Implementers should base the routing on the session or server information provided as a parameter in the sendNotification(String,int,String,AlertItem[]) method. Routing might even be possible without any routing information if there is a well known remote server for the device.

If the request cannot be routed, the Alert Sender service must immediately throw a Dmt Exception with a code of ALERT_NOT_ROUTED. The caller should not attempt to retry the sending of the notification. It is the responsibility of the Notification Service to deliver the notification to the remote management system.

117.8.1 Routing Alerts

The Notification Service allows external parties to route alerts to their destination. This mechanism enables protocol adapters to receive any alerts for systems with which they can communicate.

Such a protocol adapter should register a Remote Alert Sender service. It should provide the following service property:

- *principals* – (String[]) The array of principals to which this Remote Alert Sender service can route alerts. If this property is not registered, the

Remote Alert Sender service will be treated as the default sender. The default alert sender is only used when a more specific alert sender cannot be found.

If multiple Remote Alert Sender services register for the same principals, then the service with the highest value for the service.ranking property must be used.

117.9 Exceptions

Most of the methods of this Dmt Admin service API throw Dmt Exceptions whenever an operation fails. The DmtException class contains numeric error codes which describe the cause of the error. Some of the error codes correspond to the codes described by the OMA DM spec, while some are introduced by the OSGi Alliance. The documentation of each method describes what codes could potentially be used for that method.

The fatality of the exception decides if a thrown Exception rolls back an atomic session or not. If the isFatal() method returns true, the Exception is fatal and the session must be rolled back.

All possible error codes are constants in the DmtException class.

117.10 Events

There are two mechanisms to work with events when using the Dmt Admin service. The first mechanism is based on the Event Admin service, the second uses a traditional event listener model.

117.10.1 Event Admin based Events

The Dmt Admin service uses the Event Admin service for event delivery. For atomic sessions, events are only sent at the time the session is committed (which can happen multiple times during a session). Otherwise they are sent immediately.

Each event must carry the information of all nodes that underwent the related operation.

- info/dmtree/DmtEvent/ADDED – New nodes were added.
- info/dmtree/DmtEvent/DELETED – Existing nodes were removed.
- info/dmtree/DmtEvent/REPLACED – Existing node values or other properties were changed.
- info/dmtree/DmtEvent/RENAMED – Existing nodes were renamed.
- info/dmtree/DmtEvent/COPIED – Existing nodes were copied. A copy operation does not trigger an ADDED event (in addition to the COPIED event), even though new node(s) are created.
- info/dmtree/DmtEvent/SESSION_OPENED – A new sessions was opened.
- info/dmtree/DmtEvent/SESSION_CLOSED – A session was closed (by means of the close operation or an error).

For an atomic session, a maximum of five events can be sent: one for each operation type. In this case, the ordering for the events must follow the order of the previous list.

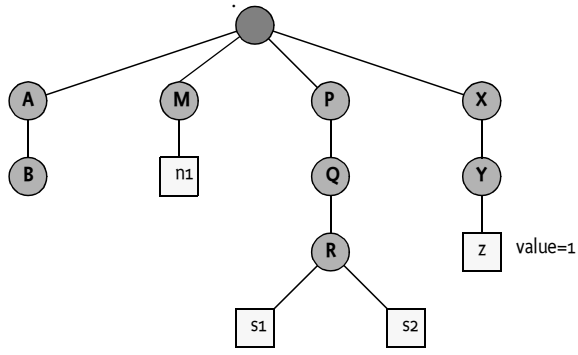
For efficiency reasons, recursive copy and delete operations must only generate a single COPIED and DELETED event for the root of the affected subtree. An event must only be sent when that type of event actually occurred.

DMT events have the following properties:

- session.id – (Integer) A unique identifier for the session that triggered the event. This property has the same value as getSessionId() of the associated DMT session.
- nodes – (String[]) The absolute URIs of each affected node. This is the nodeUri parameter of the Dmt API methods. The order of the URIs in the array corresponds to the chronological order of the operations. In case of a recursive delete, only the root URI is present in the array. Session events do not have this property.
- newnodes – (String[]) – The absolute URIs of new renamed or copied nodes. Only the RENAMED and COPIED events have this property. The newnodes array runs parallel to the nodes array. In case of a rename, newnodes[i] must contains the new name of nodes[i], and in case of a copy, newnodes[i] is the URI to which nodes[i] was copied.

The Dmt Event contains information about activities of the tree, which could be confidential. Topic Permission should be used to control access to the events. However, this permission only supports blank access, it can not restrict access for specific URIs.

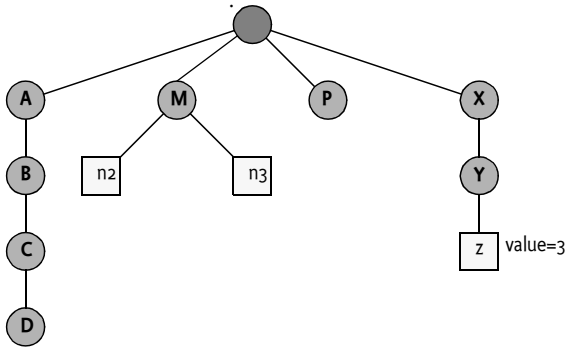
Figure 117.12 Example DMT before



For example, in a given session, when the DMT in Figure 117.12 is modified with the following operations:

- Add node ./A/B/C
- Add node ./A/B/C/D
- Rename ./M/n1 to./M/n2
- Copy ./M/n2 to ./M/n3
- Delete node ./P/Q
- Replace ./X/Y/z with 3

Figure 117.13 Example DMT after



When the Dmt Session is closed (assuming it is atomic), the following events are published by the Dmt Admin in the defined order:

```
info/dmtree/DmtEvent/ADDED {
      nodes         = [./A/B/C, ./A/B/C/D ]
      session.id    = 42
}
info/dmtree/DmtEvent/DELETED {
      nodes         = [ ./P/Q ]
      session.id    = 42
}
info/dmtree/dmt/DmtEvent/REPLACED {
      nodes         = [ ./X/Y/z ]
      session.id    = 42
}
info/dmtree/DmtEvent/RENAMED {
      nodes         = [ ./M/n1 ]
      newnodes      = [ ./M/n2 ]
      session.id    = 42
}
info/dmtree/DmtEvent/COPIED {
      nodes         = [ ./M/n2 ]
      newnodes      = [ ./M/n3 ]
      session.id    = 42
}
```

117.10.2 Event Listeners

The traditional event listener model is provided to allow compatibility with solutions that do not support an OSGi service platform.

A Dmt Event Listener is registered and unregistered with a Dmt Admin service using the following methods:

- addEventListener(int,String,DmtEventListener) – Registers an event listener on behalf of a local application. The given listener will receive notification on all changes affecting the specified subtree. An event is delivered to the registered listener if at least one affected node is within this subtree. The events can also be filtered by specifying a bit mask of relevant event types. If the listener object was already registered, it is

removed first. The listener must only see the nodes for which it has Get permission.
- addEventListener(String,int,String,DmtEventListener) – This method is the same as the previous but provides a principal on who's behalf the listening takes place. The principal must only see nodes for which it has the Get access right.
- removeEventListener(DmtEventListener) – Remove the event listener.

A Dmt Event Listener must implement the changeOccurred(DmtEvent) method. This method is called asynchronously from the actual event occurrence.

The DmtEvent object is used for the following events:

- ADDED – New nodes were added.
- DELETED – Existing nodes were removed.
- REPLACED – Existing node values or other properties were changed.
- RENAMED – Existing nodes were renamed.
- COPIED – Existing nodes were copied. A copy operation does not trigger an ADDED event (in addition to the COPIED event), even though new node(s) are created.
- SESSION_OPENED – A new session is opened. Both the nodes and the new nodes must be null for this event.
- SESSION_CLOSED – A session is closed. Both the nodes and the new nodes must be null for this event.

For efficiency reasons, recursive copy and delete operations must only generate a single COPIED and DELETED event for the root of the affected subtree. An event must only be sent when that type of event actually occurred.

The DmtEvent object can provide the following information:

- getType() – Returns the type of the event.
- getNodes() – The absolute URIs of each affected node. This is the nodeUri parameter of the Dmt API methods. The order of the URIs in the array corresponds to the chronological order of the operations. In case of a recursive delete, only the root URI is present in the array.
- getNewNodes() – The absolute URIs of new renamed or copied nodes. Only the RENAMED and COPIED events have this property.
- The newnodes array runs parallel to the nodes array. In case of a rename, newnodes[i] must contains the new name of nodes[i], and in case of a copy, newnodes[i] is the URI to which nodes[i] was copied.
- getSessionId() – The id of the session in which the event was generated.

117.11 Access Without Service Registry

The Dmt Admin can be used without access to an OSGi Service Registry. The DmtServiceFactory class provides a number of methods to access the Dmt Admin service and the Notification Service.

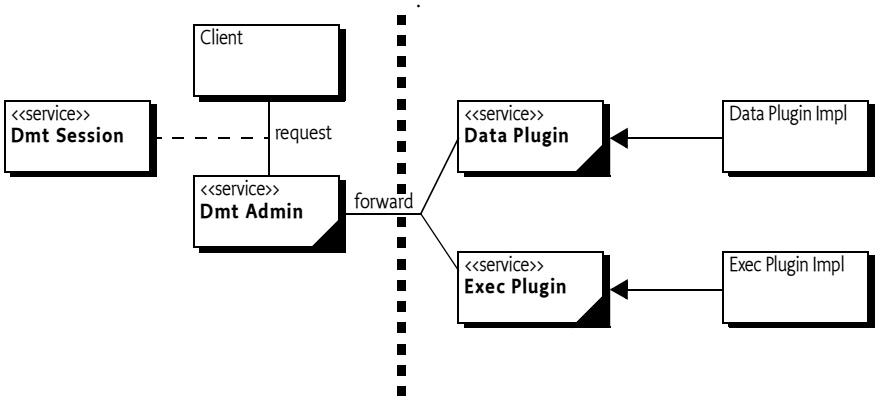
- getDmtAdmin() – Returns the Dmt Admin service for the calling application.
- getNotificationService() – Returns the Notification Service for the calling application.

117.12 Security

The Dmt Admin service specification can run on both OSGi based Service Platform (which normally requires CDC or J2SE) and CLDC based solutions. A crucial difference between these environments is the handling of security. The OSGi Service Platform uses Java 2 security with an open ended set of class based permissions while the security handling of CLDC based solutions is dependent on the profile. For example, MIDP uses a solution that uses a fixed set of permissions that are name based.

A key aspect of the Dmt Admin service model is the separation from DMT clients and plugins. The Dmt Admin service receives all the operation requests and, after verification of authority, forwards the requests to the plugins.

Figure 117.14 Separation of clients and plugins



This architecture makes it straightforward to use the OSGi security architecture to protect the different actors.

117.12.1 Principals

The caller of the getSession(String,String,int) method must have the Dmt Principal Permission with a target that matches the given principal. This Dmt Principal Permission is used to enforce that only trusted entities can act on behalf of remote managers.

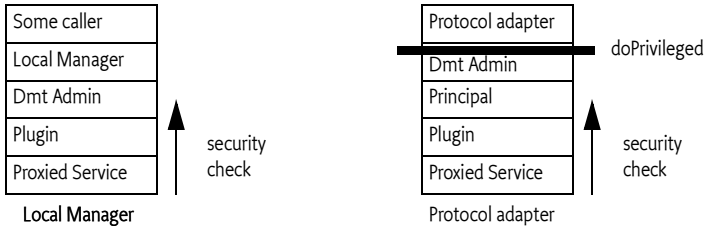
The Dmt Admin service must verify that all operations from a session with a principal can be executed on the given nodes using the available ACLs.

The other two forms of the getSession method are meant for local management applications where no principal is available. No special permission is defined to restrict the usage of these methods. The callers that want to execute device management commands, however, need to have the appropriate Dmt Permissions.

117.12.2 Operational Permissions

The operational security of a local manager and a remote manager is distinctly different. The distinction is made on the principal. Protocol adapters should use the getSession method that takes an authenticated principal. Local managers should not specify a principal.

Figure 117.15 Access control context, for local manager and protocol adapter operation



117.12.3 Protocol Adapters

A protocol adapter must provide a principal to the Dmt Admin service when it gets a session. It must use the getSession(String,String,int) method. The protocol adapter must have Dmt Principal Permission for the given principal. The Dmt Admin must then use this principal to determine the *security scope* of the given principal. This security scope is a set of permissions. How these permissions are found is not defined in this specification; they are usually in the management tree of a device. For example, the Mobile Specification stores these under the $/Policy/Java/DmtPrincipalPermission sub-tree.

Additionally, a Dmt Session with a principal implies that the Dmt Admin service must verify the ACLs on the node for all operations.

Any operation that is requested by a protocol adapter must be executed in a doPrivileged block that takes the principal's security scope. The doPrivileged block effectively hides the permissions of the protocol adapter; all operations must be performed under the security scope of the principal.

The security check for a protocol adapter is therefore as follows:

- The operation method calls doPrivileged with the security scope of the principal.
- The operation is forwarded to the appropriate plugin. The underlying service must perform its normal security checks. For example, the Configuration Admin service must check for the appropriate Configuration Permission.

The Access Control context is shown in Figure 117.15 within the protocol adapter column.

This principal-based security model allows for minimal permissions on the protocol adapter, because the Dmt Admin service performs a doPrivileged on behalf of the principal, inserting the permissions for the principal on the call stack. This model does not guard against malicious protocol adapters, though the protocol adapter must have the appropriate Dmt Principal Permission.

The protocol adapter is responsible for the authentication of the principal. The Dmt Admin must trust that the Protocol Adapter has correctly verified the identity of the other party. This specification does not address the type of authentication mechanisms that can be used. Once it has permission to use that principal, it can use any DMT command that is permitted for that principal at any time.

117.12.4 Local Manager

A local manager does not specify a principal. Security checks are therefore performed against the security scope of the local manager bundle, as shown in Figure 117.15 with the local manager stack. An operation is checked only with a Dmt Permission for the given node URI and operation. A thrown Security Exception must be passed unmodified to the caller of the operation method. The Dmt Admin service must not check the ACLs when no principal is set.

A local manager, and all its callers, must therefore have sufficient permission to handle the DMT operations as well as the permissions required by the plugins when they proxy other services (which is likely an extensive set of Permissions).

117.12.5 Plugin Security

Plugins are required to hold the maximum security scope for any services they proxy. For example, the plugin that manages the Configuration Admin service must have ConfigurationPermission("*","*") to be effective.

Plugins should not make doPrivileged calls, but should use the caller's context on the stack for permission checks.

117.12.6 Events and Permissions

The addEventListener(String,int,String,DmtEventListener) method requires Dmt Principal Permission for the given principal. In this case, the principal must have Get access to see the nodes for the event. Any nodes that the listener does not have access to must be removed from the event.

The listener registered with the addEventListener(int,String,DmtEventListener) method requires to have the appropriate Dmt Permission to receive the event.

117.12.7 Dmt Principal Permission

Execution of the getSession methods of the Dmt Admin service featuring an explicit principal name is guarded by the Dmt Principal Permission. This permission must be granted only to protocol adapters that open Dmt Sessions on behalf of remote management servers.

The DmtPrincipalPermission class does not have defined actions; it must always be created with a * to allow future extensions. The target is the principal name. A wildcard character is allowed at the end of the string to match a prefix.

Example:

```
new DmtPrincipalPermission("com.acme.dep*", "*" )
```

117.12.8 Dmt Permission

The Dmt Permission controls access to management objects in the DMT. It is intended to control only the *local* access to the DMT. The Dmt Permission target string identifies the target node's URI (absolute path is required, starting with the './' prefix) and the action field lists the management commands that are permitted on the node.

The URI can end in a wildcard character * to indicate it is a prefix that must be matched. This comparison is string based so that node boundaries can be ignored.

The following actions are defined:

- ADD
- DELETE
- EXEC
- GET
- REPLACE

For example, the following code creates a Dmt Permission for a bundle to add and replace nodes in any URI that starts with ./D.

```
new DmtPermission("./D*", "Add,Replace")
```

This permission must imply the following permission:

```
new DmtPermission("./Dev/Operator/Name", "Replace")
```

117.12.9 Alert Permission

The Alert Permission permits the holder of this permission to send a notification to a specific *target principal*. The target is identical to *Dmt Principal Permission* on page 341. No actions are defined for Alert Permission.

117.12.10 Security Summary

117.12.10.1 Dmt Admin Service and Notification Service

The Dmt Admin service is likely to require All Permission. This requirement is caused by the plugin model. Any permission required by any of the plugins must be granted to the Dmt Admin service. This set of permissions is large and hard to define. The following list shows the minimum permissions required if the plugin permissions are left out.

```
ServicePermission     ..DmtAdmin                 REGISTER
ServicePermission     ..NotificationService      REGISTER
ServicePermission     ..DataPlugin               GET
ServicePermission     ..ExecPlugin               GET
ServicePermission     ..EventAdmin               GET
ServicePermission     ..RemoteAlertSender        GET
DmtPermission         *                          *
DmtPrincipal
  Permission          *                          *
PackagePermission     info.dmtree                EXPORT
PackagePermission     info.dmtree.spi            EXPORT
PackagePermission     info.dmtree.notification   EXPORT
PackagePermission     info.dmtree.notification.spiEXPORT
```

```
PackagePermission    info.dmtree.registry       EXPORT
PackagePermission    info.dmtree.security       EXPORT
```

117.12.10.2 Data and Exec Plugin

```
ServicePermission    ..NotificationService      GET
ServicePermission    ..DataPlugin               REGISTER
ServicePermission    ..ExecPlugin               REGISTER
PackagePermission    info.dmtree                IMPORT
PackagePermission    info.dmtree.notification   IMPORT
PackagePermission    info.dmtree.spi            IMPORT
PackagePermission    info.dmtree.security       IMPORT
```

The plugin is also required to have any permissions to call its underlying services.

117.12.10.3 Local Manager

```
ServicePermission    ..DmtAdmin                 GET
PackagePermission    info.dmtree                IMPORT
PackagePermission    info.dmtree.security       IMPORT
DmtPermission        <scope>                    ...
```

Additionally, the local manager requires all permissions that are needed by the plugins it addresses.

117.12.10.4 Protocol Adapter

The Protocol adapter only requires Dmt Principal Permission for the instances that it is permitted to manage. The other permissions are taken from the security scope of the principal.

```
ServicePermission    ..DmtAdmin                 GET
ServicePermission    ..RemoteAlertSender        REGISTER
PackagePermission    info.dmtree                IMPORT
PackagePermission    info.dmtree.notification.spiIMPORT
PackagePermission    info.dmtree.notification   IMPORT
DmtPrincipalPermission<scope>
```

117.13 info.dmtree

Device Management Tree Package Version 1.0. This package contains the public API for the Device Management Tree manipulations. Permission classes are provided by the info.dmtree.security package, and DMT plugin interfaces can be found in the info.dmtree.spi package. Asynchronous notifications to remote management servers can be sent using the interfaces in the info.dmtree.notification package.

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

```
Import-Package: info.dmtree;version=1.0
```

117.13.1 Summary

- Acl - Acl is an immutable class representing structured access to DMT ACLs. [p.344]

- DmtAdmin - An interface providing methods to open sessions and register listeners. [p.347]
- DmtData - An immutable data structure representing the contents of a leaf or interior node. [p.351]
- DmtEvent - Event class storing the details of a change in the tree. [p.357]
- DmtEventListener - Registered implementations of this class are notified via DmtEvent[p.357] objects about important changes in the tree. [p.359]
- DmtException - Checked exception received when a DMT operation fails. [p.359]
- DmtIllegalStateException - Unchecked illegal state exception. [p.366]
- DmtSession - DmtSession provides concurrent access to the DMT. [p.367]
- MetaNode - The MetaNode contains meta data as standardized by OMA DM but extends it (without breaking the compatibility) to provide for better DMT data quality in an environment where many software components manipulate this data. [p.391]
- Uri - This class contains static utility methods to manipulate DMT URIs. [p.396]

117.13.2 public final class Acl

Acl is an immutable class representing structured access to DMT ACLs. Under OMA DM the ACLs are defined as strings with an internal syntax.

The methods of this class taking a principal as parameter accept remote server IDs (as passed to DmtAdmin.getSession(String, String, int) DmtAdmin.getSession[p.350]), as well as "∗ "indicating any principal.

The syntax for valid remote server IDs:
‹*server-identifier*› ::= All printable characters except '=', '&', '∗', '+' or white-space characters.

117.13.2.1 public static final int ADD = 2

Principals holding this permission can issue ADD commands on the node having this ACL.

117.13.2.2 public static final int ALL_PERMISSION = 31

Principals holding this permission can issue any command on the node having this ACL. This permission is the logical OR of ADD[p.344] , DELETE[p.344] , EXEC[p.344] , GET[p.344] and REPLACE[p.345] permissions.

117.13.2.3 public static final int DELETE = 8

Principals holding this permission can issue DELETE commands on the node having this ACL.

117.13.2.4 public static final int EXEC = 16

Principals holding this permission can issue EXEC commands on the node having this ACL.

117.13.2.5 public static final int GET = 1

Principals holding this permission can issue GET command on the node having this ACL.

117.13.2.6 public static final int REPLACE = 4

Principals holding this permission can issue REPLACE commands on the node having this ACL.

117.13.2.7 public Acl(String acl)

acl The string representation of the ACL as defined in OMA DM. If null or empty then it represents an empty list of principals with no permissions.

- Create an instance of the ACL from its canonic string representation.

Throws `IllegalArgumentException` – if acl is not a valid OMA DM ACL string

117.13.2.8 public Acl(String[] principals, int[] permissions)

principals The array of principals

permissions The array of permissions

- Creates an instance with a specified list of principals and the permissions they hold. The two arrays run in parallel, that is principals[i] will hold permissions[i] in the ACL.

  A principal name may not appear multiple times in the 'principals' argument. If the "*" principal appears in the array, the corresponding permissions will be granted to all principals (regardless of whether they appear in the array or not).

Throws `IllegalArgumentException` – if the length of the two arrays are not the same, if any array element is invalid, or if a principal appears multiple times in the principals array

117.13.2.9 public synchronized Acl addPermission(String principal, int permissions)

principal The entity to which permissions should be granted, or "*" to grant permissions to all principals.

permissions The permissions to be given. The parameter can be a logical or of more permission constants defined in this class.

- Create a new Acl instance from this Acl with the given permission added for the given principal. The already existing permissions of the principal are not affected.

Returns a new Acl instance

Throws `IllegalArgumentException` – if principal is not a valid principal name or if permissions is not a valid combination of the permission constants defined in this class

117.13.2.10 public synchronized Acl deletePermission(String principal, int permissions)

principal The entity from which permissions should be revoked, or "*" to revoke permissions from all principals.

permissions The permissions to be revoked. The parameter can be a logical or of more permission constants defined in this class.

- Create a new Acl instance from this Acl with the given permission revoked from the given principal. Other permissions of the principal are not affected.

  Note, that it is not valid to revoke a permission from a specific principal if that permission is granted globally to all principals.

Returns a new Acl instance

Throws `IllegalArgumentException` – if principal is not a valid principal name, if permissions is not a valid combination of the permission constants defined in this class, or if a globally granted permission would have been revoked from a specific principal

117.13.2.11 public boolean equals(Object obj)

obj the object to compare with this Acl instance

- Checks whether the given object is equal to this Acl instance. Two Acl instances are equal if they allow the same set of permissions for the same set of principals.

Returns true if the parameter represents the same ACL as this instance

117.13.2.12 public synchronized int getPermissions(String principal)

principal The entity whose permissions to query, or "*" to query the permissions that are granted globally, to all principals

- Get the permissions associated to a given principal.

Returns The permissions of the given principal. The returned int is a bitmask of the permission constants defined in this class

Throws `IllegalArgumentException` – if principal is not a valid principal name

117.13.2.13 public String[] getPrincipals( )

- Get the list of principals who have any kind of permissions on this node. The list only includes those principals that have been explicitly assigned permissions (so "*" is never returned), globally set permissions naturally apply to all other principals as well.

Returns The array of principals having permissions on this node.

117.13.2.14 public int hashcode( )

- Returns the hash code for this ACL instance. If two Acl instances are equal according to the `equals`[p.346] method, then calling this method on each of them must produce the same integer result.

Returns hash code for this ACL

117.13.2.15 public synchronized boolean isPermitted(String principal, int permissions)

principal The entity to check, or "*" to check whether the given permissions are granted to all principals globally

permissions The permissions to check

- Check whether the given permissions are granted to a certain principal. The requested permissions are specified as a bitfield, for example (Acl.ADD | Acl.DELETE | Acl.GET).

Returns true if the principal holds all the given permissions

Throws `IllegalArgumentException` – if principal is not a valid principal name or if permissions is not a valid combination of the permission constants defined in this class

117.13.2.16 public synchronized Acl setPermission(String principal, int permissions)

principal The entity to which permissions should be granted, or "*" to globally grant permissions to all principals.

permissions The set of permissions to be given. The parameter is a bitmask of the permission constants defined in this class.

- Create a new Acl instance from this Acl where all permissions for the given principal are overwritten with the given permissions.

  Note, that when changing the permissions of a specific principal, it is not allowed to specify a set of permissions stricter than the global set of permissions (that apply to all principals).

Returns a new Acl instance

Throws `IllegalArgumentException` – if principal is not a valid principal name, if permissions is not a valid combination of the permission constants defined in this class, or if a globally granted permission would have been revoked from a specific principal

117.13.2.17 public synchronized String toString( )

- Give the canonic string representation of this ACL. The operations are in the following order: {Add, Delete, Exec, Get, Replace}, principal names are sorted alphabetically.

Returns The string representation as defined in OMA DM.

117.13.3 public interface DmtAdmin

An interface providing methods to open sessions and register listeners. The implementation of DmtAdmin should register itself in the OSGi service registry as a service. DmtAdmin is the entry point for applications to use the DMT API.

The getSession methods are used to open a session on a specified subtree of the DMT. A typical way of usage:

```
 serviceRef = context.getServiceReference(DmtAdmin.class.get-
Name());
 DmtAdmin admin = (DmtAdmin) context.getService(serviceRef);
 DmtSession session = admin.getSession("./OSGi/Configura-
tion");
 session.createInteriorNode("./OSGi/Configuration/my.table");
```

The methods for opening a session take a node URI (the session root) as a parameter. All segments of the given URI must be within the segment length limit of the implementation, and the special characters '/' and '\'must be escaped (preceded by a '\'). Any string can be converted to a valid URI segment using the Uri.mangle(String)[p.398] method.

It is possible to specify a lock mode when opening the session (see lock type constants in DmtSession[p.367]). This determines whether the session can run in parallel with other sessions, and the kinds of operations that can be performed in the session. All Management Objects constituting the device management tree must support read operations on their nodes, while support for write operations depends on the Management Object. Management Objects supporting write access may support transactional write, non-transactional write or both. Users of DmtAdmin should consult the Management Object specification and implementation for the supported update modes. If Management Object definition permits, implementations are encouraged to support both update modes.

This interface also contains methods for manipulating the set of DmtEventListener objects that are called when the structure or content of the tree is changed. These methods are not needed in an OSGi environment, clients should register listeners through the Event Admin service.

117.13.3.1 public void addEventListener(int type, String uri, DmtEventListener listener)

type a bitmask of event types the caller is interested in

uri the URI of the root node of a subtree, must not be null

listener the listener to be registered, must not be null

- Registers an event listener on behalf of a local application. The given listener will receive notification on all changes affecting the specified subtree. The subtree is specified by its root node URI. An event is delivered to the registered listener if at least one affected node is within this subtree. The events can also be filtered by specifying a bitmask of relevant event types (e.g. DmtEvent.ADDED | DmtEvent.REPLACED | DmtEvent.SESSION_CLOSED). Only event types included in the bitmask will be delivered to the listener.

  The listener will only receive the change notifications of nodes for which the registering application has the appropriate GET info.dmtree.security.DmtPermission.

  If the specified listener was already registered, calling this method will update the registration.

Throws SecurityException – if the caller doesn't have the necessary GET DmtPermission for the given URI

NullPointerException – if the uri or listener parameter is null

IllegalArgumentException – if the type parameter contains invalid bits (not corresponding to any event type defined in DmtEvent), or if the uri parameter is invalid (is not an absolute URI or is syntactically incorrect)

117.13.3.2 public void addEventListener(String principal, int type, String uri, DmtEventListener listener)

principal the management server identity the caller is acting on behalf of, must not be null

type a bitmask of event types the caller is interested in

uri the URI of the root node of a subtree, must not be null

listener the listener to be registered, must not be null

- Registers an event listener on behalf of a remote principal. The given listener will receive notification on all changes affecting the specified subtree. The subtree is specified by its root node URI. An event is delivered to the registered listener if at least one affected node is within this subtree. The events can also be filtered by specifying a bitmask of relevant event types (e.g. DmtEvent.ADDED | DmtEvent.REPLACED | DmtEvent.SESSION_CLOSED). Only event types included in the bitmask will be delivered to the listener.

  The listener will only receive the change notifications of nodes for which the node ACL grants GET access to the specified principal.

  If the specified listener was already registered, calling this method will update the registration.

Throws `SecurityException` – if the caller doesn't have the necessary DmtPrincipalPermission to use the specified principal

`NullPointerException` – if the principal, uri or listener parameter is null

`IllegalArgumentException` – if the type parameter contains invalid bits (not corresponding to any event type defined in DmtEvent), or if the uri parameter is invalid (is not an absolute URI or is syntactically incorrect)

117.13.3.3 public DmtSession getSession(String subtreeUri) throws DmtException

subtreeUri the subtree on which DMT manipulations can be performed within the returned session

- Opens a DmtSession for local usage on a given subtree of the DMT with non transactional write lock. This call is equivalent to the following: getSession(null, subtreeUri, DmtSession.LOCK_TYPE_EXCLUSIVE)

  The subtreeUri parameter must contain an absolute URI. It can also be null, in this case the session is opened with the default session root, ".", that gives access to the whole tree.

  To perform this operation the caller must have DmtPermission for the subtreeUri node with the Get action present.

Returns a DmtSession object for the requested subtree

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if subtreeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if subtreeUri is syntactically invalid
NODE_NOT_FOUND if subtreeUri specifies a non-existing node
SESSION_CREATION_TIMEOUT if the operation timed out because of another ongoing session
COMMAND_FAILED if subtreeUri specifies a relative URI, or some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have DmtPermission for the given root node with the Get action present

117.13.3.4 public DmtSession getSession(String subtreeUri, int lockMode) throws DmtException

subtreeUri the subtree on which DMT manipulations can be performed within the returned session

lockMode one of the lock modes specified in DmtSession

- Opens a DmtSession for local usage on a specific DMT subtree with a given lock mode. This call is equivalent to the following: getSession(null, subtreeUri, lockMode)

  The subtreeUri parameter must contain an absolute URI. It can also be null, in this case the session is opened with the default session root, ".", that gives access to the whole tree.

  To perform this operation the caller must have DmtPermission for the subtreeUri node with the Get action present.

Returns a DmtSession object for the requested subtree

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if subtreeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if subtreeUri is syntactically invalid
NODE_NOT_FOUND if subtreeUri specifies a non-existing node
FEATURE_NOT_SUPPORTED if atomic sessions are not supported by the implementation and lockMode requests an atomic session
SESSION_CREATION_TIMEOUT if the operation timed out because of another ongoing session
COMMAND_FAILED if subtreeUri specifies a relative URI, if lockMode is unknown, or some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have DmtPermission for the given root node with the Get action present

117.13.3.5 public DmtSession getSession(String principal, String subtreeUri, int lockMode) throws DmtException

principal the identifier of the remote server on whose behalf the data manipulation is performed, or null for local sessions

subtreeUri the subtree on which DMT manipulations can be performed within the returned session

lockMode one of the lock modes specified in DmtSession

- Opens a DmtSession on a specific DMT subtree using a specific lock mode on behalf of a remote principal. If local management applications are using this method then they should provide null as the first parameter. Alternatively they can use other forms of this method without providing a principal string.

  The subtreeUri parameter must contain an absolute URI. It can also be null, in this case the session is opened with the default session root, ".", that gives access to the whole tree.

  This method is guarded by DmtPrincipalPermission in case of remote sessions. In addition, the caller must have Get access rights (ACL in case of remote sessions, DmtPermission in case of local sessions) on the subtreeUri node to perform this operation.

Returns a DmtSession object for the requested subtree

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if subtreeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if subtreeUri is syntactically invalid
NODE_NOT_FOUND if subtreeUri specifies a non-existing node
PERMISSION_DENIED if principal is not null and the ACL of the node does not allow the Get operation for the principal on the given root node
FEATURE_NOT_SUPPORTED if atomic sessions are not supported by the implementation and lockMode requests an atomic session
SESSION_CREATION_TIMEOUT if the operation timed out because of another ongoing session
COMMAND_FAILED if subtreeUri specifies a relative URI, if lockMode is unknown, or some unspecified error is encountered while attempting to complete the command

`SecurityException` – in case of remote sessions, if the caller does not have the required DmtPrincipalPermission with a target matching the principal parameter, or in case of local sessions, if the caller does not have DmtPermission for the given root node with the Get action present

117.13.3.6 public void removeEventListener(DmtEventListener listener)

listener the listener to be unregistered, must not be null

□ Remove a previously registered listener. After this call, the listener will not receive change notifications.

Throws `NullPointerException` – if the listener parameter is null

117.13.4 public final class DmtData

An immutable data structure representing the contents of a leaf or interior node. This structure represents only the value and the format property of the node, all other properties (like MIME type) can be set and read using the DmtSession interface.

Different constructors are available to create nodes with different formats. Nodes of null format can be created using the static NULL_VALUE[p.352] constant instance of this class.

FORMAT_RAW_BINARY[p.352] and FORMAT_RAW_STRING[p.352] enable the support of future data formats. When using these formats, the actual format name is specified as a String. The application is responsible for the proper encoding of the data according to the specified format.

117.13.4.1 public static final int FORMAT_BASE64 = 128

The node holds an OMA DM b64 value. Like FORMAT_BINARY[p.351] , this format is also represented by the Java byte[] type, the difference is only in the corresponding OMA DM format.

117.13.4.2 public static final int FORMAT_BINARY = 64

The node holds an OMA DM bin value. The value of the node corresponds to the Java byte[] type.

117.13.4.3 **public static final int FORMAT_BOOLEAN = 8**

The node holds an OMA DM bool value.

117.13.4.4 **public static final int FORMAT_DATE = 16**

The node holds an OMA DM date value.

117.13.4.5 **public static final int FORMAT_FLOAT = 2**

The node holds an OMA DM float value.

117.13.4.6 **public static final int FORMAT_INTEGER = 1**

The node holds an OMA DM int value.

117.13.4.7 **public static final int FORMAT_NODE = 1024**

Format specifier of an internal node. An interior node can hold a Java object as value (see DmtData.DmtData(Object)[p.353] and DmtData.getNode()[p.355]). This value can be used by Java programs that know a specific URI understands the associated Java type. This type is further used as a return value of the MetaNode.getFormat[p.393] method for interior nodes.

117.13.4.8 **public static final int FORMAT_NULL = 512**

The node holds an OMA DM null value. This corresponds to the Java null type.

117.13.4.9 **public static final int FORMAT_RAW_BINARY = 4096**

The node holds raw protocol data encoded in binary format. The getFormatName()[p.355] method can be used to get the actual format name.

117.13.4.10 **public static final int FORMAT_RAW_STRING = 2048**

The node holds raw protocol data encoded as String. The getFormatName()[p.355] method can be used to get the actual format name.

117.13.4.11 **public static final int FORMAT_STRING = 4**

The node holds an OMA DM chr value.

117.13.4.12 **public static final int FORMAT_TIME = 32**

The node holds an OMA DM time value.

117.13.4.13 **public static final int FORMAT_XML = 256**

The node holds an OMA DM xml value.

117.13.4.14 **public static final DmtData NULL_VALUE**

Constant instance representing a leaf node of null format.

117.13.4.15 public DmtData(String str)

str the string value to set

- Create a DmtData instance of chr format with the given string value. The null string argument is valid.

117.13.4.16 public DmtData(Object complex)

complex the complex data object to set

- Create a DmtData instance of node format with the given object value. The value represents complex data associated with an interior node.

  Certain interior nodes can support access to their subtrees through such complex values, making it simpler to retrieve or update all leaf nodes in a subtree.

  The given value must be a non-null immutable object.

117.13.4.17 public DmtData(String value, int format)

value the string, XML, date or time value to set

format the format of the DmtData instance to be created, must be one of the formats specified above

- Create a DmtData instance of the specified format and set its value based on the given string. Only the following string-based formats can be created using this constructor:
  - FORMAT_STRING[p.352] - value can be any string
  - FORMAT_XML[p.352] - value must contain an XML fragment (the validity is not checked by this constructor)
  - FORMAT_DATE[p.352] - value must be parseable to an ISO 8601 calendar date in complete representation, basic format (pattern CCYYMMDD)
  - FORMAT_TIME[p.352] - value must be parseable to an ISO 8601 time of day in either local time, complete representation, basic format (pattern hhmmss) or Coordinated Universal Time, basic format (pattern hhmmssZ)

  null string argument is only valid if the format is string or XML.

Throws IllegalArgumentException – if format is not one of the allowed formats, or value is not a valid string for the given format

NullPointerException – if a date or time is constructed and value is null

117.13.4.18 public DmtData(int integer)

integer the integer value to set

- Create a DmtData instance of int format and set its value.

117.13.4.19 public DmtData(float flt)

flt the float value to set

- Create a DmtData instance of float format and set its value.

117.13.4.20 public DmtData(boolean bool)

bool the boolean value to set

- Create a DmtData instance of bool format and set its value.

117.13.4.21 public DmtData(byte[] bytes)

bytes the byte array to set, must not be null

- Create a DmtData instance of bin format and set its value.

Throws `NullPointerException` – if bytes is null

117.13.4.22 public DmtData(byte[] bytes, boolean base64)

bytes the byte array to set, must not be null

base64 if true, the new instance will have b64 format, if false, it will have bin format

- Create a DmtData instance of bin or b64 format and set its value. The chosen format is specified by the base64 parameter.

Throws `NullPointerException` – if bytes is null

117.13.4.23 public DmtData(String formatName, String data)

formatName the name of the format, must not be null

data the data encoded according to the specified format, must not be null

- Create a DmtData instance in FORMAT_RAW_STRING[p.352] format. The data is provided encoded as a String. The actual data format is specified in formatName. The encoding used in data must conform to this format.

Throws `NullPointerException` – if formatName or data is null

117.13.4.24 public DmtData(String formatName, byte[] data)

formatName the name of the format, must not be null

data the data encoded according to the specified format, must not be null

- Create a DmtData instance in FORMAT_RAW_BINARY[p.352] format. The data is provided encoded as binary. The actual data format is specified in formatName. The encoding used in data must conform to this format.

Throws `NullPointerException` – if formatName or data is null

117.13.4.25 public boolean equals(Object obj)

obj the object to compare with this DmtData

- Compares the specified object with this DmtData instance. Two DmtData objects are considered equal if their format is the same, and their data (selected by the format) is equal.

  In case of FORMAT_RAW_BINARY[p.352] and FORMAT_RAW_STRING[p.352] the textual name of the data format - as returned by getFormatName()[p.355] - must be equal as well.

Returns true if the argument represents the same DmtData as this object

117.13.4.26 public byte[] getBase64( )

- Gets the value of a node with base 64 (b64) format.

Returns the binary value

Throws `DmtIllegalStateException` – if the format of the node is not base 64.

117.13.4.27 public byte[] getBinary( )

- Gets the value of a node with binary (bin) format.

Returns the binary value

Throws DmtIllegalStateException – if the format of the node is not binary

117.13.4.28 public boolean getBoolean( )

- Gets the value of a node with boolean (bool) format.

Returns the boolean value

Throws DmtIllegalStateException – if the format of the node is not boolean

117.13.4.29 public String getDate( )

- Gets the value of a node with date format. The returned date string is formatted according to the ISO 8601 definition of a calendar date in complete representation, basic format (pattern CCYYMMDD).

Returns the date value

Throws DmtIllegalStateException – if the format of the node is not date

117.13.4.30 public float getFloat( )

- Gets the value of a node with float format.

Returns the float value

Throws DmtIllegalStateException – if the format of the node is not float

117.13.4.31 public int getFormat( )

- Get the node's format, expressed in terms of type constants defined in this class. Note that the 'format' term is a legacy from OMA DM, it is more customary to think of this as 'type'.

Returns the format of the node

117.13.4.32 public String getFormatName( )

- Returns the format of this DmtData as String. For the predefined data formats this is the OMA DM defined name of the format. For FORMAT_RAW_STRING[p.352] and FORMAT_RAW_BINARY[p.352] this is the format specified when the object was created.

Returns the format name as String

117.13.4.33 public int getInt( )

- Gets the value of a node with integer (int) format.

Returns the integer value

Throws DmtIllegalStateException – if the format of the node is not integer

117.13.4.34 public Object getNode( )

- Gets the complex data associated with an interior node (node format).

  Certain interior nodes can support access to their subtrees through complex values, making it simpler to retrieve or update all leaf nodes in the subtree.

Returns the data object associated with an interior node

Throws DmtIllegalStateException – if the format of the data is not node

117.13.4.35 public byte[] getRawBinary( )

- Gets the value of a node in raw binary (FORMAT_RAW_BINARY[p.352]) format.

Returns the data value in raw binary format

Throws DmtIllegalStateException – if the format of the node is not raw binary

117.13.4.36 public String getRawString( )

- Gets the value of a node in raw String (FORMAT_RAW_STRING[p.352]) format.

Returns the data value in raw String format

Throws DmtIllegalStateException – if the format of the node is not raw String

117.13.4.37 public int getSize( )

- Get the size of the data. The returned value depends on the format of data in the node:
  - FORMAT_STRING[p.352] , FORMAT_XML[p.352] , FORMAT_BINARY[p.351] , FORMAT_BASE64[p.351] , FORMAT_RAW_STRING[p.352] , and FORMAT_RAW_BINARY[p.352] : the length of the stored data, or 0 if the data is null
  - FORMAT_INTEGER[p.352] and FORMAT_FLOAT[p.352] : 4
  - FORMAT_DATE[p.352] and FORMAT_TIME[p.352] : the length of the date or time in its string representation
  - FORMAT_BOOLEAN[p.351] : 1
  - FORMAT_NODE[p.352] : -1 (unknown)
  - FORMAT_NULL[p.352] : 0

Returns the size of the data stored by this object

117.13.4.38 public String getString( )

- Gets the value of a node with string (chr) format.

Returns the string value

Throws DmtIllegalStateException – if the format of the node is not string

117.13.4.39 public String getTime( )

- Gets the value of a node with time format. The returned time string is formatted according to the ISO 8601 definition of the time of day. The exact format depends on the value the object was initialized with: either local time, complete representation, basic format (pattern hhmmss) or Coordinated Universal Time, basic format (pattern hhmmssZ).

Returns the time value

Throws DmtIllegalStateException – if the format of the node is not time

117.13.4.40 public String getXml( )

- Gets the value of a node with xml format.

Returns the XML value

Throws DmtIllegalStateException – if the format of the node is not xml

117.13.4.41 public int hashCode( )

- Returns the hash code value for this DmtData instance. The hash code is calculated based on the data (selected by the format) of this object.

Returns the hash code value for this object

117.13.4.42 public String toString( )

- Gets the string representation of the DmtData. This method works for all formats.

  For string format data - including FORMAT_RAW_STRING[p.352] - the string value itself is returned, while for XML, date, time, integer, float, boolean and node formats the string form of the value is returned. Binary - including FORMAT_RAW_BINARY[p.352] - and base64 data is represented by two-digit hexadecimal numbers for each byte separated by spaces. The NULL_VALUE[p.352] data has the string form of "null". Data of string or XML format containing the Java null value is represented by an empty string.

Returns the string representation of this DmtData instance

117.13.5 public interface DmtEvent

Event class storing the details of a change in the tree. DmtEvent is used by DmtAdmin to notify registered DmtEventListener EventListeners[p.359] about important changes. Events are generated after every successful DMT change, and also when sessions are opened or closed. If a DmtSession[p.367] is opened in atomic mode, DMT events are only sent when the session is committed, when the changes are actually performed.

An event is generated for each group of nodes added, deleted, replaced, renamed or copied, in this order. Events are also generated when sessions are opened and closed.

The type of the event describes the change that triggered the event delivery. Each event carries the unique identifier of the session in which the described change happened. The events describing changes in the DMT carry the list of affected nodes. In case of COPIED[p.357] or RENAMED[p.358] events, the event carries the list of new nodes as well.

When a DmtEvent is delivered to a listener, the event contains only those node URIs that the listener has access to. This access control decision is based on the principal specified when the listener was registered:

- If the listener was registered specifying an explicit principal, using the DmtAdmin.addEventListener(String, int, String, DmtEventListener)[p.348] method, then the target node ACLs should be checked for providing GET access to the specified principal;
- When the listener was registered without an explicit principal then the listener needs GET info.dmtree.security.DmtPermission for the corresponding node.

117.13.5.1 public static final int ADDED = 1

Event type indicating nodes that were added.

117.13.5.2 public static final int COPIED = 2

Event type indicating nodes that were copied.

117.13.5.3 public static final int DELETED = 4

Event type indicating nodes that were deleted.

117.13.5.4 public static final int RENAMED = 8

Event type indicating nodes that were renamed.

117.13.5.5 public static final int REPLACED = 16

Event type indicating nodes that were replaced.

117.13.5.6 public static final int SESSION_CLOSED = 64

Event type indicating that a session was closed. This type of event is sent when the session is closed by the client or becomes inactive for any other reason (session timeout, fatal errors in business methods, etc.).

117.13.5.7 public static final int SESSION_OPENED = 32

Event type indicating that a new session was opened.

117.13.5.8 public String[] getNewNodes( )

- This method can be used to query the new nodes, when the type of the event is COPIED[p.357] or RENAMED[p.358]. For all other event types this method returns null.

  The array returned by this method runs parallel to the array returned by getNodes[p.358], the elements in the two arrays contain the source and destination URIs for the renamed or copied nodes in the same order. All returned URIs are absolute.

  This method returns only those nodes where the caller has the GET permission for the source or destination node of the operation. Therefore, it is possible that the method returns an empty array.

Returns the array of newly created nodes

117.13.5.9 public String[] getNodes( )

- This method can be used to query the subject nodes of this event. The method returns null for SESSION_OPENED[p.358] and SESSION_CLOSED[p.358].

  The method returns only those affected nodes that the caller has the GET permission for (or in case of COPIED[p.357] or RENAMED[p.358] events, where the caller has GET permissions for either the source or the destination nodes). Therefore, it is possible that the method returns an empty array. All returned URIs are absolute.

Returns the array of affected nodes

See Also getNewNodes[p.358]

117.13.5.10 public int getSessionId( )

- This method returns the identifier of the session in which this event took place. The ID is guaranteed to be unique on a machine.

Returns the unique indetifier of the session that triggered the event

117.13.5.11 public int getType( )

- This method returns the type of this event.

Returns the type of this event.

117.13.6 public interface DmtEventListener

Registered implementations of this class are notified via DmtEvent[p.357] objects about important changes in the tree. Events are generated after every successful DMT change, and also when sessions are opened or closed. If a DmtSession[p.367] is opened in atomic mode, DMT events are only sent when the session is committed, when the changes are actually performed.

117.13.6.1 public void changeOccurred(DmtEvent event)

event the DmtEvent describing the change in detail

- DmtAdmin uses this method to notify the registered listeners about the change. This method is called asynchronously from the actual event occurrence.

117.13.7 public class DmtException extends Exception

Checked exception received when a DMT operation fails. Beside the exception message, a DmtException always contains an error code (one of the constants specified in this class), and may optionally contain the URI of the related node, and information about the cause of the exception.

Some of the error codes defined in this class have a corresponding error code defined in OMA DM, in these cases the name and numerical value from OMA DM is used. Error codes without counterparts in OMA DM were given numbers from a different range, starting from 1.

The cause of the exception (if specified) can either be a single Throwable instance, or a list of such instances if several problems occurred during the execution of a method. An example for the latter is the close method of DmtSession that tries to close multiple plugins, and has to report the exceptions of all failures.

Each constructor has two variants, one accepts a String node URI, the other accepts a String[] node path. The former is used by the DmtAdmin implementation, the latter by the plugins, who receive the node URI as an array of segment names. The constructors are otherwise identical.

Getter methods are provided to retrieve the values of the additional parameters, and the printStackTrace(PrintWriter) method is extended to print the stack trace of all causing throwables as well.

117.13.7.1 public static final int ALERT_NOT_ROUTED = 5

An alert can not be sent from the device to the given principal. This can happen if there is no Remote Alert Sender willing to forward the alert to the given principal, or if no principal was given and the DmtAdmin did not find an appropriate default destination.

This error code does not correspond to any OMA DM response status code. It should be translated to the code 500 “Command Failed” when transferring over OMA DM.

117.13.7.2 public static final int COMMAND_FAILED = 500

The recipient encountered an error which prevented it from fulfilling the request.

This error code is only used in situations not covered by any of the other error codes that a method may use. Some methods specify more specific error situations for this code, but it can generally be used for any unexpected condition that causes the command to fail.

This error code corresponds to the OMA DM response status code 500 “Command Failed”.

117.13.7.3 public static final int COMMAND_NOT_ALLOWED = 405

The requested command is not allowed on the target node. This includes the following situations:

- an interior node operation is requested for a leaf node, or vice versa (e.g. trying to retrieve the children of a leaf node)
- an attempt is made to create a node where the parent is a leaf node
- an attempt is made to rename or delete the root node of the tree
- an attempt is made to rename or delete the root node of the session
- a write operation (other than setting the ACL) is performed in a non-atomic write session on a node provided by a plugin that is read-only or does not support non-atomic writing
- a node is copied to its descendant
- the ACL of the root node is changed not to include Add rights for all principals

This error code corresponds to the OMA DM response status code 405 “Command not allowed”.

117.13.7.4 public static final int CONCURRENT_ACCESS = 4

An error occurred related to concurrent access of nodes. This can happen for example if a configuration node was deleted directly through the Configuration Admin service, while the node was manipulated via the tree.

This error code does not correspond to any OMA DM response status code. It should be translated to the code 500 “Command Failed” when transferring over OMA DM.

117.13.7.5 public static final int DATA_STORE_FAILURE = 510

An error related to the recipient data store occurred while processing the request. This error code may be thrown by any of the methods accessing the tree, but whether it is really used depends on the implementation, and the data store it uses.

This error code corresponds to the OMA DM response status code 510 “Data store failure”.

117.13.7.6 public static final int FEATURE_NOT_SUPPORTED = 406

The requested command failed because an optional feature required by the command is not supported. For example, opening an atomic session might return this error code if the DmtAdmin implementation does not support transactions. Similarly, accessing the optional node properties (Title, Timestamp, Version, Size) might not succeed if either the DmtAdmin implementation or the underlying plugin does not support the property.

When getting or setting values for interior nodes (an optional optimization feature), a plugin can use this error code to indicate that the given interior node does not support values.

This error code corresponds to the OMA DM response status code 406 "Optional feature not supported".

117.13.7.7 public static final int INVALID_URI = 3

The requested command failed because the target URI or node name is null or syntactically invalid. This covers the following cases:

- the URI or node name ends with the '\'or '/' character
- the URI is an empty string (only invalid if the method does not accept relative URIs)
- the URI contains the segment "." at a position other than the beginning of the URI
- the node name is ".." or the URI contains such a segment
- the node name is an empty string or the URI contains an empty segment
- the node name contains an unescaped '/' character

See the Uri.mangle(String)[p.398] method for support on escaping invalid characters in a URI.

This code is only used if the URI or node name does not match any of the criteria for URI_TOO_LONG[p.363] . This error code does not correspond to any OMA DM response status code. It should be translated to the code 404 "Not Found" when transferring over OMA DM.

117.13.7.8 public static final int METADATA_MISMATCH = 2

Operation failed because of meta data restrictions. This covers any attempted deviation from the parameters defined by the MetaNode objects of the affected nodes, for example in the following situations:

- creating, deleting or renaming a permanent node, or modifying its type or value
- creating an interior node where the meta-node defines it as a leaf, or vice versa
- any operation on a node which does not have the required access type (e.g. executing a node that lacks the MetaNode.CMD_EXECUTE access type)
- any node creation or deletion that would violate the cardinality constraints
- any leaf node value setting that would violate the allowed formats, values, mime types, etc.
- any node creation that would violate the allowed node names

This error code can also be used to indicate any other meta data violation, even if it cannot be described by the MetaNode class. For example, detecting a multi-node constraint violation while committing an atomic session should result in this error.

This error code does not correspond to any OMA DM response status code. It should be translated to the code 405 “Command not allowed” when transferring over OMA DM.

117.13.7.9 public static final int NODE_ALREADY_EXISTS = 418

The requested node creation operation failed because the target already exists. This can occur if the node is created directly (with one of the create... methods), or indirectly (during a copy operation).

This error code corresponds to the OMA DM response status code 418 “Already exists”.

117.13.7.10 public static final int NODE_NOT_FOUND = 404

The requested target node was not found. No indication is given as to whether this is a temporary or permanent condition, unless otherwise noted.

This is only used when the requested node name is valid, otherwise the more specific error codes URI_TOO_LONG[p.363] or INVALID_URI[p.361] are used. This error code corresponds to the OMA DM response status code 404 “Not Found”.

117.13.7.11 public static final int PERMISSION_DENIED = 425

The requested command failed because the principal associated with the session does not have adequate access control permissions (ACL) on the target. This can only appear in case of remote sessions, i.e. if the session is associated with an authenticated principal.

This error code corresponds to the OMA DM response status code 425 “Permission denied”.

117.13.7.12 public static final int REMOTE_ERROR = 1

A device initiated remote operation failed. This is used when the protocol adapter fails to send an alert for any reason.

Alert routing errors (that occur while looking for the proper protocol adapter to use) are indicated by ALERT_NOT_ROUTED[p.359] , this code is only for errors encountered while sending the routed alert. This error code does not correspond to any OMA DM response status code. It should be translated to the code 500 “Command Failed” when transferring over OMA DM.

117.13.7.13 public static final int ROLLBACK_FAILED = 516

The rollback command was not completed successfully. The tree might be in an inconsistent state after this error.

This error code corresponds to the OMA DM response status code 516 “Atomic roll back failed”.

117.13.7.14 public static final int SESSION_CREATION_TIMEOUT = 7

Creation of a session timed out because of another ongoing session. The length of time while the DmtAdmin waits for the blocking session(s) to finish is implementation dependant.

This error code does not correspond to any OMA DM response status code. OMA has several status codes related to timeout, but these are meant to be used when a request times out, not if a session can not be established. This error code should be translated to the code 500 “Command Failed” when transferring over OMA DM.

117.13.7.15 public static final int TRANSACTION_ERROR = 6

A transaction-related error occurred in an atomic session. This error is caused by one of the following situations:

- an updating method within an atomic session can not be executed because the underlying plugin is read-only or does not support atomic writing
- a commit operation at the end of an atomic session failed because one of the underlying plugins failed to close

The latter case may leave the tree in an inconsistent state due to the lack of a two-phase commit system, see DmtSession.commit[p.368] for details.

This error code does not correspond to any OMA DM response status code. It should be translated to the code 500 “Command Failed” when transferring over OMA DM.

117.13.7.16 public static final int UNAUTHORIZED = 401

The originator’s authentication credentials specify a principal with insufficient rights to complete the command.

This status code is used as response to device originated sessions if the remote management server cannot authorize the device to perform the requested operation.

This error code corresponds to the OMA DM response status code 401 “Unauthorized”.

117.13.7.17 public static final int URI_TOO_LONG = 414

The requested command failed because the target URI or one of its segments is too long for what the recipient is able or willing to process, or the target URI contains too many segments. The length and segment number limits are implementation dependent, their minimum values can be found in the Non Functional Requirements section of the OSGi specification.

The Uri.mangle(String)[p.398] method provides support for ensuring that a URI segment conforms to the length limits set by the implementation.

This error code corresponds to the OMA DM response status code 414 “URI too long”.

See Also OSGi Service Platform, Mobile Specification Release 4

117.13.7.18 public DmtException(String uri, int code, String message)

uri the node on which the failed DMT operation was issued, or null if the operation is not associated with a node

code the error code of the failure

message the message associated with the exception, or null if there is no error message

- Create an instance of the exception. The uri and message parameters are optional. No originating exception is specified.

117.13.7.19 public DmtException(String uri, int code, String message, Throwable cause)

uri the node on which the failed DMT operation was issued, or null if the operation is not associated with a node

code the error code of the failure

message the message associated with the exception, or null if there is no error message

cause the originating exception, or null if there is no originating exception

- Create an instance of the exception, specifying the cause exception. The uri, message and cause parameters are optional.

117.13.7.20 public DmtException(String uri, int code, String message, Vector causes, boolean fatal)

uri the node on which the failed DMT operation was issued, or null if the operation is not associated with a node

code the error code of the failure

message the message associated with the exception, or null if there is no error message

causes the list of originating exceptions, or empty list or null if there are no originating exceptions

fatal whether the exception is fatal

- Create an instance of the exception, specifying the list of cause exceptions and whether the exception is a fatal one. This constructor is meant to be used by plugins wishing to indicate that a serious error occurred which should invalidate the ongoing atomic session. The uri, message and causes parameters are optional.

  If a fatal exception is thrown, no further business methods will be called on the originator plugin. In case of atomic sessions, all other open plugins will be rolled back automatically, except if the fatal exception was thrown during commit.

117.13.7.21 public DmtException(String[] path, int code, String message)

path the path of the node on which the failed DMT operation was issued, or null if the operation is not associated with a node

code the error code of the failure

message the message associated with the exception, or null if there is no error message

- Create an instance of the exception, specifying the target node as an array of path segments. This method behaves in exactly the same way as if the path was given as a URI string.

See Also `DmtException(String, int, String)` [p.363]

117.13.7.22 public DmtException(String[] path, int code, String message, Throwable cause)

path the path of the node on which the failed DMT operation was issued, or null if the operation is not associated with a node

code the error code of the failure

message the message associated with the exception, or null if there is no error message

cause the originating exception, or null if there is no originating exception

- Create an instance of the exception, specifying the target node as an array of path segments, and specifying the cause exception. This method behaves in exactly the same way as if the path was given as a URI string.

See Also `DmtException(String, int, String, Throwable)` [p.364]

117.13.7.23 public DmtException(String[] path, int code, String message, Vector causes, boolean fatal)

path the path of the node on which the failed DMT operation was issued, or null if the operation is not associated with a node

code the error code of the failure

message the message associated with the exception, or null if there is no error message

causes the list of originating exceptions, or empty list or null if there are no originating exceptions

fatal whether the exception is fatal

- Create an instance of the exception, specifying the target node as an array of path segments, the list of cause exceptions, and whether the exception is a fatal one. This method behaves in exactly the same way as if the path was given as a URI string.

See Also `DmtException(String, int, String, Vector, boolean)` [p.364]

117.13.7.24 public Throwable getCause( )

- Get the cause of this exception. Returns non-null, if this exception is caused by one or more other exceptions (like a NullPointerException in a DmtPlugin). If there are more than one cause exceptions, the first one is returned.

Returns the cause of this exception, or null if no cause was given

117.13.7.25 public Throwable[] getCauses( )

- Get all causes of this exception. Returns the causing exceptions in an array. If no cause was specified, an empty array is returned.

Returns the list of causes of this exception

117.13.7.26 public int getCode( )

- Get the error code associated with this exception. Most of the error codes within this exception correspond to OMA DM error codes.

Returns the error code

117.13.7.27 public String getMessage( )

- Get the message associated with this exception. The returned string also contains the associated URI (if any) and the exception code. The resulting message has the following format (parts in square brackets are only included if the field inside them is not null):

```
<exception_code>[: '<uri>'][: <error_message>]
```

Returns the error message in the format described above

117.13.7.28 public String getURI( )

- Get the node on which the failed DMT operation was issued. Some operations like DmtSession.close() don't require an URI, in this case this method returns null.

Returns the URI of the node, or null

117.13.7.29 public boolean isFatal( )

- Check whether this exception is marked as fatal in the session. Fatal exceptions trigger an automatic rollback of atomic sessions.

Returns whether the exception is marked as fatal

117.13.7.30 public void printStackTrace(PrintStream s)

s PrintStream to use for output

- Prints the exception and its backtrace to the specified print stream. Any causes that were specified for this exception are also printed, together with their backtraces.

117.13.8 public class DmtIllegalStateException extends RuntimeException

Unchecked illegal state exception. This class is used in DMT because java.lang.IllegalStateException does not exist in CLDC.

117.13.8.1 public DmtIllegalStateException( )

- Create an instance of the exception with no message.

117.13.8.2 public DmtIllegalStateException(String message)

message the reason for the exception

- Create an instance of the exception with the specified message.

117.13.8.3 public DmtIllegalStateException(Throwable cause)

cause the cause of the exception

- Create an instance of the exception with the specified cause exception and no message.

117.13.8.4 public DmtIllegalStateException(String message, Throwable cause)

message the reason for the exception

cause the cause of the exception

- Create an instance of the exception with the specified message and cause exception.

117.13.8.5 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

117.13.9 public interface DmtSession

DmtSession provides concurrent access to the DMT. All DMT manipulation commands for management applications are available on the DmtSession interface. The session is associated with a root node which limits the subtree in which the operations can be executed within this session.

Most of the operations take a node URI as parameter, which can be either an absolute URI (starting with "./") or a URI relative to the root node of the session. The empty string as relative URI means the root URI the session was opened with. All segments of a URI must be within the segment length limit of the implementation, and the special characters '/' and '\'must be escaped (preceded by a '\'). Any string can be converted to a valid URI segment using the Uri.mangle(String)[p.398] method.

If the URI specified does not correspond to a legitimate node in the tree an exception is thrown. The only exception is the isNodeUri(String)[p.385] method which returns false in case of an invalid URI.

Each method of DmtSession that accesses the tree in any way can throw DmtIllegalStateException if the session has been closed or invalidated (due to timeout, fatal exceptions, or unexpectedly unregistered plugins).

117.13.9.1 public static final int LOCK_TYPE_ATOMIC = 2

LOCK_TYPE_ATOMIC is an exclusive lock with transactional functionality. Commands of an atomic session will either fail or succeed together, if a single command fails then the whole session will be rolled back.

117.13.9.2 public static final int LOCK_TYPE_EXCLUSIVE = 1

LOCK_TYPE_EXCLUSIVE lock guarantees full access to the tree, but can not be shared with any other locks.

117.13.9.3 public static final int LOCK_TYPE_SHARED = 0

Sessions created with LOCK_TYPE_SHARED lock allows read-only access to the tree, but can be shared between multiple readers.

117.13.9.4 public static final int STATE_CLOSED = 1

The session is closed, DMT manipulation operations are not available, they throw DmtIllegalStateException if tried.

117.13.9.5 public static final int STATE_INVALID = 2

The session is invalid because a fatal error happened. Fatal errors include the timeout of the session, any DmtException with the 'fatal' flag set, or the case when a plugin service is unregistered while in use by the session. DMT manipulation operations are not available, they throw DmtIllegalStateException if tried.

117.13.9.6 public static final int STATE_OPEN = 0

The session is open, all session operations are available.

117.13.9.7 public void close( ) throws DmtException

- Closes a session. If the session was opened with atomic lock mode, the DmtSession must first persist the changes made to the DMT by calling commit() on all (transactional) plugins participating in the session. See the documentation of the commit[p.368] method for details and possible errors during this operation.

  The state of the session changes to DmtSession.STATE_CLOSED if the close operation completed successfully, otherwise it becomes DmtSession.STATE_INVALID.

Throws `DmtException` – with the following possible error codes:
METADATA_MISMATCH in case of atomic sessions, if the commit operation failed because of meta-data restrictions
CONCURRENT_ACCESS in case of atomic sessions, if the commit operation failed because of some modification outside the scope of the DMT to the nodes affected in the session
TRANSACTION_ERROR in case of atomic sessions, if an underlying plugin failed to commit
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if an underlying plugin failed to close, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.13.9.8 public void commit( ) throws DmtException

- Commits a series of DMT operations issued in the current atomic session since the last transaction boundary. Transaction boundaries are the creation of this object that starts the session, and all subsequent commit[p.368] and rollback[p.386] calls.

  This method can fail even if all operations were successful. This can happen due to some multi-node semantic constraints defined by a specific implementation. For example, node A can be required to always have children A/B, A/C and A/D. If this condition is broken when commit() is executed, the method will fail, and throw a METADATA_MISMATCH exception.

  An error situation can arise due to the lack of a two phase commit mechanism in the underlying plugins. As an example, if plugin A has committed successfully but plugin B failed, the whole session must fail, but there is no way to undo the commit performed by A. To provide predictable behaviour,

the commit operation should continue with the remaining plugins even after detecting a failure. All exceptions received from failed commits are aggregated into one TRANSACTION_ERROR exception thrown by this method.

In many cases the tree is not the only way to manage a given part of the system. It may happen that while modifying some nodes in an atomic session, the underlying settings are modified in parallel outside the scope of the DMT. If this is detected during commit, an exception with the code CONCURRENT_ACCESS is thrown.

Throws `DmtException` – with the following possible error codes:
METADATA_MISMATCH if the operation failed because of meta-data restrictions
CONCURRENT_ACCESS if it is detected that some modification has been made outside the scope of the DMT to the nodes affected in the session's operations
TRANSACTION_ERROR if an error occurred during the commit of any of the underlying plugins
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session was not opened using the LOCK_TYPE_ATOMIC lock type, or if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.13.9.9 public void copy(String nodeUri, String newNodeUri, boolean recursive) throws DmtException

nodeUri the node or root of a subtree to be copied

newNodeUri the URI of the new node or root of a subtree

recursive false if only a single node is copied, true if the whole subtree is copied

□ Create a copy of a node or a whole subtree. Beside the structure and values of the nodes, most properties are also copied, with the exception of the ACL (Access Control List), Timestamp and Version properties.

The copy method is essentially a convenience method that could be substituted with a sequence of retrieval and update operations. This determines the permissions required for copying. However, some optimization can be possible if the source and target nodes are all handled by DmtAdmin or by the same plugin. In this case, the handler might be able to perform the underlying management operation more efficiently: for example, a configuration table can be copied at once instead of reading each node for each entry and creating it in the new tree.

This method may result in any of the errors possible for the contributing operations. Most of these are collected in the exception descriptions below, but for the full list also consult the documentation of `getChildNodeNames(String)`[p.378] , `isLeafNode(String)`[p.384] ,

getNodeValue(String)[p.383], getNodeType(String)[p.382], getNodeTitle(String)[p.382], setNodeTitle(String, String)[p.388], createLeafNode(String, DmtData, String)[p.375] and createInteriorNode(String, String)[p.371].

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or newNodeUri or any segment of them is too long, or if they have too many segments
INVALID_URI if nodeUri or newNodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node, or if newNodeUri points to a node that cannot exist in the tree according to the meta-data (see getMetaNode(String))
NODE_ALREADY_EXISTS if newNodeUri points to a node that already exists
PERMISSION_DENIED if the session is associated with a principal and the ACL of the copied node(s) does not allow the Get operation, or the ACL of the parent of the target node does not allow the Add operation for the associated principal
COMMAND_NOT_ALLOWED if nodeUri is an ancestor of newNodeUri, or if any of the implied retrieval or update operations are not allowed
METADATA_MISMATCH if any of the meta-data constraints of the implied retrieval or update operations are violated
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if either URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the copied node(s) with the Get action present, or for the parent of the target node with the Add action

117.13.9.10 public void createInteriorNode(String nodeUri) throws DmtException

nodeUri the URI of the node to create

□ Create an interior node. If the parent node does not exist, it is created automatically, as if this method were called for the parent URI. This way all missing ancestor nodes leading to the specified node are created. Any exceptions encountered while creating the ancestors are propagated to the caller of this method, these are not explicitly listed in the error descriptions below.

If meta-data is available for the node, several checks are made before creating it. The node must have MetaNode.CMD_ADD access type, it must be defined as a non-permanent interior node, the node name must conform to the valid names, and the creation of the new node must not cause the maximum occurrence number to be exceeded.

If the meta-data cannot be retrieved because the given node cannot possibly exist in the tree (it is not defined in the specification), the NODE_NOT_FOUND error code is returned (see getMetaNode(String)[p.379]).

Throws DmtException – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a node that cannot exist in the tree (see above)
NODE_ALREADY_EXISTS if nodeUri points to a node that already exists
PERMISSION_DENIED if the session is associated with a principal and the ACL of the parent node does not allow the Add operation for the associated principal
COMMAND_NOT_ALLOWED if the parent node is not an interior node, or in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node could not be created because of meta-data restrictions (see above)
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

DmtIllegalStateException – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the parent node with the Add action present

117.13.9.11 public void createInteriorNode(String nodeUri, String type) throws DmtException

nodeUri the URI of the node to create

type the type URI of the interior node, can be null if no node type is defined

□ Create an interior node with a given type. The type of interior node, if specified, is a URI identifying a DDF document. If the parent node does not exist, it is created automatically, as if createInteriorNode(String)[p.370] were called for the parent URI. This way all missing ancestor nodes leading to the specified node are created. Any exceptions encountered while creating the ancestors are propagated to the caller of this method, these are not explicitly listed in the error descriptions below.

If meta-data is available for the node, several checks are made before creating it. The node must have MetaNode.CMD_ADD access type, it must be defined as a non-permanent interior node, the node name must conform to the valid names, and the creation of the new node must not cause the maximum occurrence number to be exceeded.

If the meta-data cannot be retrieved because the given node cannot possibly exist in the tree (it is not defined in the specification), the NODE_NOT_FOUND error code is returned (see getMetaNode(String)[p.379]).

Interior node type identifiers must follow the format defined in section 7.7.7.2 of the OMA Device Management Tree and Description document. Checking the validity of the type string does not have to be done by the DmtAdmin, this can be left to the plugin handling the node (if any), to avoid unnecessary double-checks.

Throws DmtException – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a node that cannot exist in the tree (see above)
NODE_ALREADY_EXISTS if nodeUri points to a node that already exists
PERMISSION_DENIED if the session is associated with a principal and the ACL of the parent node does not allow the Add operation for the associated principal
COMMAND_NOT_ALLOWED if the parent node is not an interior node, or in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node could not be created because of meta-data restrictions (see above)
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, if the type string is invalid (see above), or if some unspecified error is encountered while attempting to complete the command

DmtIllegalStateException – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the parent node with the Add action present

See Also createInteriorNode(String)[p.370] , OMA Device Management Tree and Description v1.2 draft (http://member.openmobilealliance.org/ftp/public_documents/dm/Permanent_documents/OMA-TS-DM-TND-V1_2-20050615-C.zip)

117.13.9.12 public void createLeafNode(String nodeUri) throws DmtException

nodeUri the URI of the node to create

□ Create a leaf node with default value and MIME type. If a node does not have a default value or MIME type, this method will throw a DmtException with error code METADATA_MISMATCH. Note that a node might have a default value or MIME type even if there is no meta-data for the node or its meta-data does not specify the default.

If the parent node does not exist, it is created automatically, as if createInteriorNode(String)[p.370] were called for the parent URI. This way all missing ancestor nodes leading to the specified node are created. Any exceptions encountered while creating the ancestors are propagated to the caller of this method, these are not explicitly listed in the error descriptions below.

If meta-data is available for a node, several checks are made before creating it. The node must have MetaNode.CMD_ADD access type, it must be defined as a non-permanent leaf node, the node name must conform to the valid names, and the creation of the new node must not cause the maximum occurrence number to be exceeded.

If the meta-data cannot be retrieved because the given node cannot possibly exist in the tree (it is not defined in the specification), the NODE_NOT_FOUND error code is returned (see getMetaNode(String)[p.379]).

Throws DmtException – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a node that cannot exist in the tree (see above)
NODE_ALREADY_EXISTS if nodeUri points to a node that already exists
PERMISSION_DENIED if the session is associated with a principal and the ACL of the parent node does not allow the Add operation for the associated principal
COMMAND_NOT_ALLOWED if the parent node is not an interior node, or in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node could not be created because of meta-data restrictions (see above)
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

DmtIllegalStateException – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the parent node with the Add action present

See Also createLeafNode(String, DmtData)[p.373]

117.13.9.13 public void createLeafNode(String nodeUri, DmtData value) throws DmtException

nodeUri the URI of the node to create

value the value to be given to the new node, can be null

- Create a leaf node with a given value and the default MIME type. If the specified value is null, the default value is taken. If the node does not have a default MIME type or value (if needed), this method will throw a DmtException with error code METADATA_MISMATCH. Note that a node might have a default value or MIME type even if there is no meta-data for the node or its meta-data does not specify the default.

  If the parent node does not exist, it is created automatically, as if createInteriorNode(String)[p.370] were called for the parent URI. This way all missing ancestor nodes leading to the specified node are created. Any exceptions encountered while creating the ancestors are propagated to the caller of this method, these are not explicitly listed in the error descriptions below.

  If meta-data is available for a node, several checks are made before creating it. The node must have MetaNode.CMD_ADD access type, it must be defined as a non-permanent leaf node, the node name must conform to the valid names, the node value must conform to the value constraints, and the creation of the new node must not cause the maximum occurrence number to be exceeded.

  If the meta-data cannot be retrieved because the given node cannot possibly exist in the tree (it is not defined in the specification), the NODE_NOT_FOUND error code is returned (see getMetaNode(String)[p.379]).

  Nodes of null format can be created by using DmtData.NULL_VALUE[p.352] as second argument.

Throws DmtException – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a node that cannot exist in the tree (see above)
NODE_ALREADY_EXISTS if nodeUri points to a node that already exists
PERMISSION_DENIED if the session is associated with a principal and the ACL of the parent node does not allow the Add operation for the associated principal
COMMAND_NOT_ALLOWED if the parent node is not an interior node, or in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node could not be created because of meta-data restrictions (see above)
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

DmtIllegalStateException – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the parent node with the Add action present

117.13.9.14 public void createLeafNode(String nodeUri, DmtData value, String mimeType) throws DmtException

nodeUri the URI of the node to create

value the value to be given to the new node, can be null

mimeType the MIME type to be given to the new node, can be null

- Create a leaf node with a given value and MIME type. If the specified value or MIME type is null, their default values are taken. If the node does not have the necessary defaults, this method will throw a DmtException with error code METADATA_MISMATCH. Note that a node might have a default value or MIME type even if there is no meta-data for the node or its meta-data does not specify the default.

  If the parent node does not exist, it is created automatically, as if createInteriorNode(String)[p.370] were called for the parent URI. This way all missing ancestor nodes leading to the specified node are created. Any exceptions encountered while creating the ancestors are propagated to the caller of this method, these are not explicitly listed in the error descriptions below.

  If meta-data is available for a node, several checks are made before creating it. The node must have MetaNode.CMD_ADD access type, it must be defined as a non-permanent leaf node, the node name must conform to the valid names, the node value must conform to the value constraints, the MIME type must be among the listed types, and the creation of the new node must not cause the maximum occurrence number to be exceeded.

  If the meta-data cannot be retrieved because the given node cannot possibly exist in the tree (it is not defined in the specification), the NODE_NOT_FOUND error code is returned (see getMetaNode(String)[p.379]).

  Nodes of null format can be created by using DmtData.NULL_VALUE[p.352] as second argument.

  The MIME type string must conform to the definition in RFC 2045. Checking its validity does not have to be done by the DmtAdmin, this can be left to the plugin handling the node (if any), to avoid unnecessary double-checks.

Throws DmtException – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a node that cannot exist in the tree (see above)
NODE_ALREADY_EXISTS if nodeUri points to a node that already exists
PERMISSION_DENIED if the session is associated with a principal and the ACL of the parent node does not allow the Add operation for the associated principal
COMMAND_NOT_ALLOWED if the parent node is not an interior node, or

in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node could not be created because of meta-data restrictions (see above)
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, if mimeType is not a proper MIME type string (see above), or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the parent node with the Add action present

See Also `createLeafNode(String, DmtData)` [p.373], RFC 2045 (http://www.ietf.org/rfc/rfc2045.txt)

117.13.9.15 public void deleteNode(String nodeUri) throws DmtException

nodeUri the URI of the node

- Delete the given node. Deleting interior nodes is recursive, the whole subtree under the given node is deleted. It is not allowed to delete the root node of the session.

  If meta-data is available for a node, several checks are made before deleting it. The node must be non-permanent, it must have the MetaNode.CMD_DELETE access type, and if zero occurrences of the node are not allowed, it must not be the last one.

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Delete operation for the associated principal
COMMAND_NOT_ALLOWED if the target node is the root of the session, or in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node could not be deleted because of meta-data restrictions (see above)
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

DmtIllegalStateException – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Delete action present

117.13.9.16 public void execute(String nodeUri, String data) throws DmtException

nodeUri the node on which the execute operation is issued

data the parameter of the execute operation, can be null

□ Executes a node. This corresponds to the EXEC operation in OMA DM. This method cannot be called in a read-only session.

The semantics of an execute operation and the data parameter it takes depends on the definition of the managed object on which the command is issued.

Throws DmtException – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if the node does not exist and the plugin does not allow executing unexisting nodes
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Execute operation for the associated principal
METADATA_MISMATCH if the node cannot be executed according to the meta-data (does not have MetaNode.CMD_EXECUTE access type)
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, if no DmtExecPlugin is associated with the node and the DmtAdmin can not execute the node, or if some unspecified error is encountered while attempting to complete the command

DmtIllegalStateException – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Exec action present

See Also execute(String, String, String) [p.377]

117.13.9.17 public void execute(String nodeUri, String correlator, String data) throws DmtException

nodeUri the node on which the execute operation is issued

correlator an identifier to associate this operation with any notifications sent in response to it, can be null if not needed

data the parameter of the execute operation, can be null

- Executes a node, also specifying a correlation ID for use in response notifications. This operation corresponds to the EXEC command in OMA DM. This method cannot be called in a read-only session.

  The semantics of an execute operation and the data parameter it takes depends on the definition of the managed object on which the command is issued. If a correlation ID is specified, it should be used as the correlator parameter for notifications sent in response to this execute operation.

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if the node does not exist and the plugin does not allow executing unexisting nodes
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Execute operation for the associated principal
METADATA_MISMATCH if the node cannot be executed according to the meta-data (does not have MetaNode.CMD_EXECUTE access type)
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, if no DmtExecPlugin is associated with the node, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Exec action present

See Also `execute(String, String)`[p.377]

117.13.9.18 public String[] getChildNodeNames(String nodeUri) throws DmtException

nodeUri the URI of the node

- Get the list of children names of a node. The returned array contains the names - not the URIs - of the immediate children nodes of the given node. The returned child names are mangled (`Uri.mangle`[p.398]). The elements are in no particular order. The returned array must not contain null entries.

Returns the list of child node names as a string array or an empty string array if the node has no children

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
COMMAND_NOT_ALLOWED if the specified node is not an interior node
METADATA_MISMATCH if node information cannot be retrieved accord-

ing to the meta-data (it does not have MetaNode.CMD_GET access type)
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

117.13.9.19 public Acl getEffectiveNodeAcl(String nodeUri) throws DmtException

nodeUri the URI of the node

- Gives the Access Control List in effect for a given node. The returned Acl takes inheritance into account, that is if there is no ACL defined for the node, it will be derived from the closest ancestor having an ACL defined.

Returns the Access Control List belonging to the node

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
METADATA_MISMATCH if node information cannot be retrieved according to the meta-data (the node does not have MetaNode.CMD_GET access type)
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

See Also `getNodeAcl`[p.380]

117.13.9.20 public int getLockType( )

- Gives the type of lock the session has.

Returns the lock type of the session, one of LOCK_TYPE_SHARED[p.367], LOCK_TYPE_EXCLUSIVE[p.367] and LOCK_TYPE_ATOMIC[p.367]

117.13.9.21 public MetaNode getMetaNode(String nodeUri) throws DmtException

nodeUri the URI of the node

- Get the meta data which describes a given node. Meta data can only be inspected, it can not be changed.

The MetaNode object returned to the client is the combination of the meta data returned by the data plugin (if any) plus the meta data returned by the DmtAdmin. If there are differences in the meta data elements known by the plugin and the DmtAdmin then the plugin specific elements take precedence.

Note, that a node does not have to exist for having meta-data associated with it. This method may provide meta-data for any node that can possibly exist in the tree (any node defined in the specification). For nodes that are not defined, it may throw DmtException with the error code NODE_NOT_FOUND. To allow easier implementation of plugins that do not provide meta-data, it is allowed to return null for any node, regardless of whether it is defined or not.

Returns a MetaNode which describes meta data information, can be null if there is no meta data available for the given node

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a node that is not defined in the tree (see above)
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

117.13.9.22 public Acl getNodeAcl(String nodeUri) throws DmtException

nodeUri the URI of the node

□ Get the Access Control List associated with a given node. The returned Acl object does not take inheritance into account, it gives the ACL specifically given to the node.

Returns the Access Control List belonging to the node or null if none defined

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
METADATA_MISMATCH if node information cannot be retrieved according to the meta-data (the node does not have MetaNode.CMD_GET access type)
DATA_STORE_FAILURE if an error occurred while accessing the data store

COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

See Also `getEffectiveNodeAcl`[p.379]

117.13.9.23 public int getNodeSize(String nodeUri) throws DmtException

nodeUri the URI of the leaf node

□ Get the size of the data in a leaf node. The returned value depends on the format of the data in the node, see the description of the `DmtData.getSize()`[p.356] method for the definition of node size for each format.

Returns the size of the data in the node

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
COMMAND_NOT_ALLOWED if the specified node is not a leaf node
METADATA_MISMATCH if node information cannot be retrieved according to the meta-data (it does not have MetaNode.CMD_GET access type)
FEATURE_NOT_SUPPORTED if the Size property is not supported by the DmtAdmin implementation or the underlying plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

See Also `DmtData.getSize`[p.356]

117.13.9.24 public Date getNodeTimestamp(String nodeUri) throws DmtException

nodeUri the URI of the node

□ Get the timestamp when the node was created or last modified.

Returns the timestamp of the last modification

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node

PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
METADATA_MISMATCH if node information cannot be retrieved according to the meta-data (it does not have MetaNode.CMD_GET access type)
FEATURE_NOT_SUPPORTED if the Timestamp property is not supported by the DmtAdmin implementation or the underlying plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

117.13.9.25 public String getNodeTitle(String nodeUri) throws DmtException

nodeUri the URI of the node

- Get the title of a node. There might be no title property set for a node.

Returns the title of the node, or null if the node has no title

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
METADATA_MISMATCH if node information cannot be retrieved according to the meta-data (it does not have MetaNode.CMD_GET access type)
FEATURE_NOT_SUPPORTED if the Title property is not supported by the DmtAdmin implementation or the underlying plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

117.13.9.26 public String getNodeType(String nodeUri) throws DmtException

nodeUri the URI of the node

- Get the type of a node. The type of leaf node is the MIME type of the data it contains. The type of an interior node is a URI identifying a DDF document; a null type means that there is no DDF document overriding the tree structure defined by the ancestors.

Returns the type of the node, can be null

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
METADATA_MISMATCH if node information cannot be retrieved according to the meta-data (it does not have MetaNode.CMD_GET access type)
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

117.13.9.27 public DmtData getNodeValue(String nodeUri) throws DmtException

nodeUri the URI of the node to retrieve

□ Get the data contained in a leaf or interior node. When retrieving the value associated with an interior node, the caller must have rights to read all nodes in the subtree under the given node.

Returns the data of the node, can not be null

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node (and the ACLs of all its descendants in case of interior nodes) do not allow the Get operation for the associated principal
METADATA_MISMATCH if the node value cannot be retrieved according to the meta-data (it does not have MetaNode.CMD_GET access type)
FEATURE_NOT_SUPPORTED if the specified node is an interior node and does not support Java object values
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node (and all its descendants in case of interior nodes) with the Get action present

117.13.9.28 public int getNodeVersion(String nodeUri) throws DmtException

nodeUri the URI of the node

- Get the version of a node. The version can not be set, it is calculated automatically by the device. It is incremented modulo 0x10000 at every modification of the value or any other property of the node, for both leaf and interior nodes. When a node is created the initial value is 0.

Returns the version of the node

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
METADATA_MISMATCH if node information cannot be retrieved according to the meta-data (it does not have MetaNode.CMD_GET access type)
FEATURE_NOT_SUPPORTED if the Version property is not supported by the DmtAdmin implementation or the underlying plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

117.13.9.29 public String getPrincipal( )

- Gives the name of the principal on whose behalf the session was created. Local sessions do not have an associated principal, in this case null is returned.

Returns the identifier of the remote server that initiated the session, or null for local sessions

117.13.9.30 public String getRootUri( )

- Get the root URI associated with this session. Gives "." if the session was created without specifying a root, which means that the target of this session is the whole DMT.

Returns the root URI

117.13.9.31 public int getSessionId( )

- The unique identifier of the session. The ID is generated automatically, and it is guaranteed to be unique on a machine.

Returns the session identification number

117.13.9.32 public int getState( )

- Get the current state of this session.

Returns the state of the session, one of STATE_OPEN[p.368] , STATE_CLOSED[p.367] and STATE_INVALID[p.368]

117.13.9.33 public boolean isLeafNode(String nodeUri) throws DmtException

nodeUri the URI of the node

□ Tells whether a node is a leaf or an interior node of the DMT.

Returns true if the given node is a leaf node

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Get operation for the associated principal
METADATA_MISMATCH if node information cannot be retrieved according to the meta-data (it does not have MetaNode.CMD_GET access type)
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

117.13.9.34 public boolean isNodeUri(String nodeUri)

nodeUri the URI to check

□ Check whether the specified URI corresponds to a valid node in the DMT.

Returns true if the given node exists in the DMT

Throws `DmtIllegalStateException` – if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Get action present

117.13.9.35 public void renameNode(String nodeUri, String newName) throws DmtException

nodeUri the URI of the node to rename

newName the new name property of the node

□ Rename a node. This operation only changes the name of the node (updating the timestamp and version properties if they are supported), the value and the other properties are not changed. The new name of the node must be provided, the new URI is constructed from the base of the old URI and the given name. It is not allowed to rename the root node of the session.

If available, the meta-data of the original and the new nodes are checked before performing the rename operation. Neither node can be permanent, their leaf/interior property must match, and the name change must not violate any of the cardinality constraints. The original node must have the MetaNode.CMD_REPLACE access type, and the name of the new node must conform to the valid names.

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, if nodeUri has too many segments, or if newName is too long
INVALID_URI if nodeUri or newName is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node, or if the new node is not defined in the tree according to the meta-data (see getMetaNode(String))
NODE_ALREADY_EXISTS if there already exists a sibling of nodeUri with the name newName
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Replace operation for the associated principal
COMMAND_NOT_ALLOWED if the target node is the root of the session, or in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node could not be renamed because of meta-data restrictions (see above)
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Replace action present

117.13.9.36 public void rollback( ) throws DmtException

□ Rolls back a series of DMT operations issued in the current atomic session since the last transaction boundary. Transaction boundaries are the creation of this object that starts the session, and all subsequent `commit`[p.368] and `rollback`[p.386] calls.

Throws `DmtException` – with the error code ROLLBACK_FAILED in case the rollback did not succeed

`DmtIllegalStateException` – if the session was not opened using the LOCK_TYPE_ATOMIC lock type, or if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.13.9.37 public void setDefaultNodeValue(String nodeUri) throws DmtException

nodeUri the URI of the node

- Set the value of a leaf or interior node to its default. The default can be defined by the node's MetaNode. The method throws a METADATA_MISMATCH exception if the node does not have a default value.

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Replace operation for the associated principal
COMMAND_NOT_ALLOWED in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node is permanent or cannot be modified according to the meta-data (does not have the MetaNode.CMD_REPLACE access type), or if there is no default value defined for this node
FEATURE_NOT_SUPPORTED if the specified node is an interior node and does not support Java object values
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Replace action present

See Also `setNodeValue`[p.390]

117.13.9.38 public void setNodeAcl(String nodeUri, Acl acl) throws DmtException

nodeUri the URI of the node

acl the Access Control List to be set on the node, can be null

- Set the Access Control List associated with a given node. To perform this operation, the caller needs to have replace rights (Acl.REPLACE or the corresponding Java permission depending on the session type) as described below:
  - if nodeUri specifies a leaf node, replace rights are needed on the parent of the node
  - if nodeUri specifies an interior node, replace rights on either the node or its parent are sufficient

If the given acl is null or an empty ACL (not specifying any permissions for any principals), then the ACL of the node is deleted, and the node will inherit the ACL from its parent node.

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node or its parent (see above) does not allow the Replace operation for the associated principal
COMMAND_NOT_ALLOWED if the command attempts to set the ACL of the root node not to include Add rights for all principals
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

`SecurityException` – in case of local sessions, if the caller does not have DmtPermission for the node or its parent (see above) with the Replace action present

117.13.9.39 public void setNodeTitle(String nodeUri, String title) throws DmtException

nodeUri the URI of the node

title the title text of the node, can be null

- Set the title property of a node. The length of the title string in UTF-8 encoding must not exceed 255 bytes.

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Replace operation for the associated principal
COMMAND_NOT_ALLOWED in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node cannot be modified according to the meta-data (does not have the MetaNode.CMD_REPLACE access type)
FEATURE_NOT_SUPPORTED if the Title property is not supported by the DmtAdmin implementation or the underlying plugin
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the title string is too long, if the URI is not within the

current session's subtree, or if some unspecified error is encountered while attempting to complete the command

`DmtIllegalStateException` – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Replace action present

117.13.9.40 public void setNodeType(String nodeUri, String type) throws DmtException

nodeUri the URI of the node

type the type of the node, can be null

□ Set the type of a node. The type of leaf node is the MIME type of the data it contains. The type of an interior node is a URI identifying a DDF document.

For interior nodes, a null type string means that there is no DDF document overriding the tree structure defined by the ancestors. For leaf nodes, it requests that the default MIME type is used for the given node. If the node does not have a default MIME type this method will throw a DmtException with error code METADATA_MISMATCH. Note that a node might have a default MIME type even if there is no meta-data for the node or its meta-data does not specify the default.

MIME types must conform to the definition in RFC 2045. Interior node type identifiers must follow the format defined in section 7.7.7.2 of the OMA Device Management Tree and Description document. Checking the validity of the type string does not have to be done by the DmtAdmin, this can be left to the plugin handling the node (if any), to avoid unnecessary double-checks.

Throws `DmtException` – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Replace operation for the associated principal
COMMAND_NOT_ALLOWED in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node is permanent or cannot be modified according to the meta-data (does not have the MetaNode.CMD_REPLACE access type), and in case of leaf nodes, if null is given and there is no default MIME type, or the given MIME type is not allowed
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree, if the type string is invalid (see above), or if some unspecified error is encountered while attempting to complete the command

DmtIllegalStateException – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Replace action present

See Also RFC 2045 (http://www.ietf.org/rfc/rfc2045.txt) , OMA Device Management Tree and Description v1.2 draft (http://member.openmobilealliance.org/ftp/public_documents/dm/Permanent_documents/OMA-TS-DM-TND-V1_2-20050615-C.zip)

117.13.9.41 public void setNodeValue(String nodeUri, DmtData data) throws DmtException

nodeUri the URI of the node

data the data to be set, can be null

- Set the value of a leaf or interior node. The format of the node is contained in the DmtData object. For interior nodes, the format must be FORMAT_NODE, while for leaf nodes this format must not be used.

  If the specified value is null, the default value is taken. In this case, if the node does not have a default value, this method will throw a DmtException with error code METADATA_MISMATCH. Nodes of null format can be set by using DmtData.NULL_VALUE[p.352] as second argument.

  An Event of type REPLACE is sent out for a leaf node. A replaced interior node sends out events for each of its children in depth first order and node names sorted with Arrays.sort(String[]). When setting a value on an interior node, the values of the leaf nodes under it can change, but the structure of the subtree is not modified by the operation.

Throws DmtException – with the following possible error codes:
URI_TOO_LONG if nodeUri or a segment of it is too long, or if it has too many segments
INVALID_URI if nodeUri is null or syntactically invalid
NODE_NOT_FOUND if nodeUri points to a non-existing node
PERMISSION_DENIED if the session is associated with a principal and the ACL of the node does not allow the Replace operation for the associated principal
COMMAND_NOT_ALLOWED if the given data has FORMAT_NODE format but the node is a leaf node (or vice versa), or in non-atomic sessions if the underlying plugin is read-only or does not support non-atomic writing
METADATA_MISMATCH if the node is permanent or cannot be modified according to the meta-data (does not have the MetaNode.CMD_REPLACE access type), or if the given value does not conform to the meta-data value constraints
FEATURE_NOT_SUPPORTED if the specified node is an interior node and does not support Java object values
TRANSACTION_ERROR in an atomic session if the underlying plugin is read-only or does not support atomic writing
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if the URI is not within the current session's subtree,

or if some unspecified error is encountered while attempting to complete the command

DmtIllegalStateException – if the session was opened using the LOCK_TYPE_SHARED lock type, or if the session is already closed or invalidated

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation, or, in case of local sessions, if the caller does not have DmtPermission for the node with the Replace action present

117.13.10 public interface MetaNode

The MetaNode contains meta data as standardized by OMA DM but extends it (without breaking the compatibility) to provide for better DMT data quality in an environment where many software components manipulate this data.

The interface has several types of functions to describe the nodes in the DMT. Some methods can be used to retrieve standard OMA DM metadata such as access type, cardinality, default, etc., others are for data extensions such as valid names and values. In some cases the standard behaviour has been extended, for example it is possible to provide several valid MIME types, or to differentiate between normal and automatic dynamic nodes.

Most methods in this interface receive no input, just return information about some aspect of the node. However, there are two methods that behave differently, isValidName[p.395] and isValidValue[p.396] . These validation methods are given a potential node name or value (respectively), and can decide whether it is valid for the given node. Passing the validation methods is a necessary condition for a name or value to be used, but it is not necessarily sufficient: the plugin may carry out more thorough (more expensive) checks when the node is actually created or set.

If a MetaNode is available for a node, the DmtAdmin must use the information provided by it to filter out invalid requests on that node. However, not all methods on this interface are actually used for this purpose, as many of them (e.g. getFormat[p.393] or getValidNames[p.395]) can be substituted with the validating methods. For example, isValidValue[p.396] can be expected to check the format, minimum, maximum, etc. of a given value, making it unnecessary for the DmtAdmin to call getFormat()[p.393] , getMin()[p.394] , getMax()[p.393] etc. separately. It is indicated in the description of each method if the DmtAdmin does not enforce the constraints defined by it - such methods are only for external use, for example in user interfaces.

Most of the methods of this class return null if a certain piece of meta information is not defined for the node or providing this information is not supported. Methods of this class do not throw exceptions.

117.13.10.1 public static final int AUTOMATIC = 2

Constant for representing an automatic node in the tree. This must be returned by getScope()[p.395] for all nodes that are created automatically by the management object. Automatic nodes represent a special case of dynamic nodes, so this scope should be mapped to DYNAMIC[p.392] when used in an OMA DM context.

An automatic node is usually created instantly when its parent is created, but it is also valid if it only appears later, triggered by some other condition. The exact behaviour must be defined by the Management Object.

117.13.10.2 public static final int CMD_ADD = 0

Constant for the ADD access type. If can(int)[p.392] returns true for this operation, this node can potentially be added to its parent. Nodes with PERMANENT[p.392] or AUTOMATIC[p.391] scope typically do not have this access type.

117.13.10.3 public static final int CMD_DELETE = 1

Constant for the DELETE access type. If can(int)[p.392] returns true for this operation, the node can potentially be deleted.

117.13.10.4 public static final int CMD_EXECUTE = 2

Constant for the EXECUTE access type. If can(int)[p.392] returns true for this operation, the node can potentially be executed.

117.13.10.5 public static final int CMD_GET = 4

Constant for the GET access type. If can(int)[p.392] returns true for this operation, the value, the list of child nodes (in case of interior nodes) and the properties of the node can potentially be retrieved.

117.13.10.6 public static final int CMD_REPLACE = 3

Constant for the REPLACE access type. If can(int)[p.392] returns true for this operation, the value and other properties of the node can potentially be modified.

117.13.10.7 public static final int DYNAMIC = 1

Constant for representing a dynamic node in the tree. This must be returned by getScope[p.395] for all nodes that are not permanent and are not created automatically by the management object.

117.13.10.8 public static final int PERMANENT = 0

Constant for representing a permanent node in the tree. This must be returned by getScope[p.395] if the node cannot be added, deleted or modified in any way through tree operations. Permanent nodes cannot have non-permanent nodes as parents.

117.13.10.9 public boolean can(int operation)

operation One of the MetaNode.CMD_... constants.

- Check whether the given operation is valid for this node. If no meta-data is provided for a node, all operations are valid.

Returns false if the operation is not valid for this node or the operation code is not one of the allowed constants

117.13.10.10 public DmtData getDefault( )

- Get the default value of this node if any.

Returns The default value or null if not defined

117.13.10.11 public String getDescription( )

- Get the explanation string associated with this node. Can be null if no description is provided for this node.

Returns node description string or null for no description

117.13.10.12 public Object getExtensionProperty(String key)

key the key for the extension property

- Returns the value for the specified extension property key. This method only works if the provider of this MetaNode provides proprietary extensions to node meta data.

Returns the value of the requested property, cannot be null

Throws `IllegalArgumentException` – if the specified key is not supported by this MetaNode

117.13.10.13 public String[] getExtensionPropertyKeys( )

- Returns the list of extension property keys, if the provider of this MetaNode provides proprietary extensions to node meta data. The method returns null if the node doesn't provide such extensions.

Returns the array of supported extension property keys

117.13.10.14 public int getFormat( )

- Get the node's format, expressed in terms of type constants defined in DmtData[p.351] . If there are multiple formats allowed for the node then the format constants are OR-ed. Interior nodes must have DmtData.FORMAT_NODE[p.352] format, and this code must not be returned for leaf nodes. If no meta-data is provided for a node, all applicable formats are considered valid (with the above constraints regarding interior and leaf nodes).

  Note that the 'format' term is a legacy from OMA DM, it is more customary to think of this as 'type'.

  The formats returned by this method are not checked by DmtAdmin, they are only for external use, for example in user interfaces. DmtAdmin only calls isValidValue[p.396] for checking the value, its behaviour should be consistent with this method.

Returns the allowed format(s) of the node

117.13.10.15 public double getMax( )

- Get the maximum allowed value associated with a node of numeric format. If no meta-data is provided for a node, there is no upper limit to its value. This method is only meaningful if the node has integer or float format. The returned limit has double type, as this can be used to denote both integer and float limits with full precision. The actual maximum should be the largest integer or float number that does not exceed the returned value.

  The information returned by this method is not checked by DmtAdmin, it is only for external use, for example in user interfaces. DmtAdmin only calls isValidValue[p.396] for checking the value, its behaviour should be consistent with this method.

Returns the allowed maximum, or Double.MAX_VALUE if there is no upper limit defined or the node's format is not integer or float

117.13.10.16 public int getMaxOccurrence( )

- Get the number of maximum occurrences of this type of nodes on the same level in the DMT. Returns Integer.MAX_VALUE if there is no upper limit. Note that if the occurrence is greater than 1 then this node can not have siblings with different metadata. In other words, if different types of nodes coexist on the same level, their occurrence can not be greater than 1. If no meta-data is provided for a node, there is no upper limit on the number of occurrences.

Returns The maximum allowed occurrence of this node type

117.13.10.17 public String[] getMimeTypes( )

- Get the list of MIME types this node can hold. The first element of the returned list must be the default MIME type.

  All MIME types are considered valid if no meta-data is provided for a node or if null is returned by this method. In this case the default MIME type cannot be retrieved from the meta-data, but the node may still have a default. This hidden default (if it exists) can be utilized by passing null as the type parameter of DmtSession.setNodeType(String, String)[p.389] or DmtSession.createLeafNode(String, DmtData, String)[p.375].

Returns the list of allowed MIME types for this node, starting with the default MIME type, or null if all types are allowed

117.13.10.18 public double getMin( )

- Get the minimum allowed value associated with a node of numeric format. If no meta-data is provided for a node, there is no lower limit to its value. This method is only meaningful if the node has integer or float format. The returned limit has double type, as this can be used to denote both integer and float limits with full precision. The actual minimum should be the smallest integer or float number that is larger than the returned value.

  The information returned by this method is not checked by DmtAdmin, it is only for external use, for example in user interfaces. DmtAdmin only calls isValidValue[p.396] for checking the value, its behaviour should be consistent with this method.

Returns the allowed minimum, or Double.MIN_VALUE if there is no lower limit defined or the node's format is not integer or float

117.13.10.19 public String[] getRawFormatNames( )

- Get the format names for any raw formats supported by the node. This method is only meaningful if the list of supported formats returned by getFormat()[p.393] contains DmtData.FORMAT_RAW_STRING[p.352] or DmtData.FORMAT_RAW_BINARY[p.352]: it specifies precisely which raw format(s) are actually supported. If the node cannot contain data in one of the raw types, this method must return null.

  The format names returned by this method are not checked by DmtAdmin, they are only for external use, for example in user interfaces. DmtAdmin only calls isValidValue[p.396] for checking the value, its behaviour should be consistent with this method.

Returns the allowed format name(s) of raw data stored by the node, or null if raw formats are not supported

117.13.10.20 public int getScope( )

- Return the scope of the node. Valid values are PERMANENT MetaNode.PERMANENT[p.392], DYNAMIC MetaNode.DYNAMIC[p.392] and AUTOMATIC MetaNode.AUTOMATIC[p.391]. Note that a permanent node is not the same as a node where the DELETE operation is not allowed. Permanent nodes never can be deleted, whereas a non-deletable node can disappear in a recursive DELETE operation issued on one of its parents. If no meta-data is provided for a node, it can be assumed to be a dynamic node.

Returns PERMANENT[p.392] for permanent nodes, AUTOMATIC[p.391] for nodes that are automatically created, and DYNAMIC[p.392] otherwise

117.13.10.21 public String[] getValidNames( )

- Return an array of Strings if valid names are defined for the node, or null if no valid name list is defined or if this piece of meta info is not supported. If no meta-data is provided for a node, all names are considered valid.

  The information returned by this method is not checked by DmtAdmin, it is only for external use, for example in user interfaces. DmtAdmin only calls isValidName[p.395] for checking the name, its behaviour should be consistent with this method.

Returns the valid values for this node name, or null if not defined

117.13.10.22 public DmtData[] getValidValues( )

- Return an array of DmtData objects if valid values are defined for the node, or null otherwise. If no meta-data is provided for a node, all values are considered valid.

  The information returned by this method is not checked by DmtAdmin, it is only for external use, for example in user interfaces. DmtAdmin only calls isValidValue[p.396] for checking the value, its behaviour should be consistent with this method.

Returns the valid values for this node, or null if not defined

117.13.10.23 public boolean isLeaf( )

- Check whether the node is a leaf node or an internal one.

Returns true if the node is a leaf node

117.13.10.24 public boolean isValidName(String name)

name the node name to check for validity

- Checks whether the given name is a valid name for this node. This method can be used for example to ensure that the node name is always one of a predefined set of valid names, or that it matches a specific pattern. This method should be consistent with the values returned by getValidNames[p.395] (if any), the DmtAdmin only calls this method for name validation.

  This method may return true even if not all aspects of the name have been checked, expensive operations (for example those that require external resources) need not be performed here. The actual node creation may still indicate that the node name is invalid.

Returns false if the specified name is found to be invalid for the node described by this meta-node, true otherwise

117.13.10.25 public boolean isValidValue(DmtData value)

value the value to check for validity

- Checks whether the given value is valid for this node. This method can be used to ensure that the value has the correct format and range, that it is well formed, etc. This method should be consistent with the constraints defined by the getFormat[p.393] , getValidValues[p.395] , getMin[p.394] and getMax[p.393] methods (if applicable), as the Dmt Admin only calls this method for value validation.

  This method may return true even if not all aspects of the value have been checked, expensive operations (for example those that require external resources) need not be performed here. The actual value setting method may still indicate that the value is invalid.

Returns false if the specified value is found to be invalid for the node described by this meta-node, true otherwise

117.13.10.26 public boolean isZeroOccurrenceAllowed( )

- Check whether zero occurrence of this node is valid. If no meta-data is returned for a node, zero occurrences are allowed.

Returns true if zero occurrence of this node is valid

117.13.11 public final class Uri

This class contains static utility methods to manipulate DMT URIs.

Syntax of valid DMT URIs:

- A slash ('/' \u002F) is the separator of the node names. Slashes used in node name must therefore be escaped using a backslash slash ("\/"). The backslash must be escaped with a double backslash sequence. A backslash found must be ignored when it is not followed by a slash or backslash.
- The node name can be constructed using full Unicode character set (except the Supplementary code, not being supported by CLDC/CDC). However, using the full Unicode character set for node names is discouraged because the encoding in the underlying storage as well as the encoding needed in communications can create significant performance

and memory usage overhead. Names that are restricted to the URI set [-a-zA-Z0-9_.!~*'()] are most efficient.
- URIs used in the DMT must be treated and interpreted as case sensitive.
- No End Slash: URI must not end with the delimiter slash ('/' \u002F). This implies that the root node must be denoted as "." and not "./".
- No parent denotation: URI must not be constructed using the character sequence "../" to traverse the tree upwards.
- Single Root: The character sequence "./" must not be used anywhere else but in the beginning of a URI.

117.13.11.1 public static int getMaxSegmentNameLength( )

□ Returns the maximum allowed length of a URI segment. The value is implementation specific. The length of the URI segment is defined as the number of bytes in the unescaped, UTF-8 encoded represenation of the segment.

The return value of Integer.MAX_VALUE indicates that there is no upper limit on the length of segment names.

Returns maximum URI segment length supported by the implementation

117.13.11.2 public static int getMaxUriLength( )

□ Returns the maximum allowed length of a URI. The value is implementation specific. The length of the URI is defined as the number of bytes in the unescaped, UTF-8 encoded represenation of the URI.

The return value of Integer.MAX_VALUE indicates that there is no upper limit on the length of URIs.

Returns maximum URI length supported by the implementation

117.13.11.3 public static int getMaxUriSegments( )

□ Returns the maximum allowed number of URI segments. The returned value is implementation specific.

The return value of Integer.MAX_VALUE indicates that there is no upper limit on the number of URI segments.

Returns maximum number of URI segments supported by the implementation

117.13.11.4 public static boolean isAbsoluteUri(String uri)

uri the URI to be checked, must not be null and must contain a valid URI

□ Checks whether the specified URI is an absolute URI. An absolute URI contains the complete path to a node in the DMT starting from the DMT root (".").

Returns whether the specified URI is absolute

Throws `NullPointerException` – if the specified URI is null

`IllegalArgumentException` – if the specified URI is malformed

117.13.11.5 public static boolean isValidUri(String uri)

uri the URI to be validated

□ Checks whether the specified URI is valid. A URI is considered valid if it meets the following constraints:

- the URI is not null;

- the URI follows the syntax defined for valid DMT URIs;
- the length of the URI is not more than getMaxUriLength()[p.397] ;
- the URI doesn't contain more than getMaxUriSegments()[p.397] segments;
- the length of each segment of the URI is less than or equal to getMaxSegmentNameLength()[p.397] .

getMaxUriLength() and getMaxSegmentNameLength() methods.

Returns whether the specified URI is valid

117.13.11.6 public static String mangle(String nodeName)

nodeName the node name to be mangled (if necessary), must not be null or empty

□ Returns a node name that is valid for the tree operation methods, based on the given node name. This transformation is not idempotent, so it must not be called with a parameter that is the result of a previous mangle method call.

Node name mangling is needed in the following cases:

- if the name contains '/' or '\'characters
- if the length of the name exceeds the limit defined by the implementation

A node name that does not suffer from either of these problems is guaranteed to remain unchanged by this method. Therefore the client may skip the mangling if the node name is known to be valid (though it is always safe to call this method).

The method returns the normalized nodeName as described below. Invalid node names are normalized in different ways, depending on the cause. If the length of the name does not exceed the limit, but the name contains '/' or '\'characters, then these are simply escaped by inserting an additional '\'before each occurrence. If the length of the name does exceed the limit, the following mechanism is used to normalize it:

- the SHA 1 digest of the name is calculated
- the digest is encoded with the base 64 algorithm
- all '/' characters in the encoded digest are replaced with '_'
- trailing '=' signs are removed

Returns the normalized node name that is valid for tree operations

Throws NullPointerException – if nodeName is null

IllegalArgumentException – if nodeName is empty

117.13.11.7 public static String[] toPath(String uri)

uri the URI to be split, must not be null

□ Split the specified URI along the path separator '/' charaters and return an array of URI segments. Special characters in the returned segments are escaped. The returned array may be empty if the specifed URI was empty.

Returns an array of URI segments created by splitting the specified URI

Throws NullPointerException – if the specified URI is null

IllegalArgumentException – if the specified URI is malformed

117.13.11.8 public static String toUri(String[] path)

path a possibly empty array of URI segments, must not be null

□ Construct a URI from the specified URI segments. The segments must already be mangled.

If the specified path is an empty array then an empty URI ("") is returned.

Returns the URI created from the specified segments

Throws `NullPointerException` – if the specified path or any of its segments are null

`IllegalArgumentException` – if the specified path contains too many or malformed segments or the resulting URI is too long

117.14 info.dmtree.spi

Device Management Tree SPI Package Version 1.0. This package contains the interface classes that compose the Device Management SPI (Service Provider Interface). These interfaces are implemented by DMT plugins; users of the DmtAdmin interface do not interact directly with these.

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

```
Import-Package: info.dmtree.spi;version=1.0
```

117.14.1 Summary

- DataPlugin - An implementation of this interface takes the responsibility of handling data requests in a subtree of the DMT. [p.399]
- ExecPlugin - An implementation of this interface takes the responsibility of handling node execute requests requests in a subtree of the DMT. [p.401]
- ReadableDataSession - Provides read-only access to the part of the tree handled by the plugin that created this session. [p.402]
- ReadWriteDataSession - Provides non-atomic read-write access to the part of the tree handled by the plugin that created this session. [p.407]
- TransactionalDataSession - Provides atomic read-write access to the part of the tree handled by the plugin that created this session. [p.412]

117.14.2 public interface DataPlugin

An implementation of this interface takes the responsibility of handling data requests in a subtree of the DMT.

In an OSGi environment such implementations should be registered at the OSGi service registry specifying the list of root node URIs in a String array in the dataRootURIs registration parameter.

When the first reference in a session is made to a node handled by this plugin, the DmtAdmin calls one of the open... methods to retrieve a plugin session object for processing the request. The called method depends on the lock type of the current session. In case of `openReadWriteSession(String[], DmtSession)`[p.401] and `openAtomicSession(String[],`

DmtSession)[p.400], the plugin may return null to indicate that the specified lock type is not supported. In this case the DmtAdmin may call openReadOnlySession(String[], DmtSession)[p.400] to start a read-only plugin session, which can be used as long as there are no write operations on the nodes handled by this plugin.

The sessionRoot parameter of each method is a String array containing the segments of the URI pointing to the root of the session. This is an absolute path, so the first segment is always ".". Special characters appear escaped in the segments.

117.14.2.1 public TransactionalDataSession openAtomicSession(String[] sessionRoot, DmtSession session) throws DmtException

sessionRoot the path to the subtree which is locked in the current session, must not be null

session the session from which this plugin instance is accessed, must not be null

- This method is called to signal the start of an atomic read-write session when the first reference is made within a DmtSession to a node which is handled by this plugin. Session information is given as it is needed for sending alerts back from the plugin.

  The plugin can assume that there are no other sessions open on any subtree that has any overlap with the subtree of this session.

Returns a plugin session capable of executing read-write operations in an atomic block, or null if the plugin does not support atomic read-write sessions

Throws DmtException – with the following possible error codes:
NODE_NOT_FOUND if sessionRoot points to a non-existing node
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

SecurityException – if some underlying operation failed because of lack of permissions

117.14.2.2 public ReadableDataSession openReadOnlySession(String[] sessionRoot, DmtSession session) throws DmtException

sessionRoot the path to the subtree which is accessed in the current session, must not be null

session the session from which this plugin instance is accessed, must not be null

- This method is called to signal the start of a read-only session when the first reference is made within a DmtSession to a node which is handled by this plugin. Session information is given as it is needed for sending alerts back from the plugin.

  The plugin can assume that there are no writing sessions open on any subtree that has any overlap with the subtree of this session.

Returns a plugin session capable of executing read operations

Throws DmtException – with the following possible error codes:
NODE_NOT_FOUND if sessionRoot points to a non-existing node
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

SecurityException – if some underlying operation failed because of lack of permissions

117.14.2.3 public ReadWriteDataSession openReadWriteSession(String[] sessionRoot, DmtSession session) throws DmtException

sessionRoot the path to the subtree which is locked in the current session, must not be null

session the session from which this plugin instance is accessed, must not be null

- This method is called to signal the start of a non-atomic read-write session when the first reference is made within a DmtSession to a node which is handled by this plugin. Session information is given as it is needed for sending alerts back from the plugin.

  The plugin can assume that there are no other sessions open on any subtree that has any overlap with the subtree of this session.

Returns a plugin session capable of executing read-write operations, or null if the plugin does not support non-atomic read-write sessions

Throws DmtException – with the following possible error codes:
NODE_NOT_FOUND if sessionRoot points to a non-existing node
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

SecurityException – if some underlying operation failed because of lack of permissions

117.14.3 public interface ExecPlugin

An implementation of this interface takes the responsibility of handling node execute requests requests in a subtree of the DMT.

In an OSGi environment such implementations should be registered at the OSGi service registry specifying the list of root node URIs in a String array in the execRootURIs registration parameter.

117.14.3.1 public void execute(DmtSession session, String[] nodePath, String correlator, String data) throws DmtException

session a reference to the session in which the operation was issued, must not be null

nodePath the absolute path of the node to be executed, must not be null

correlator an identifier to associate this operation with any alerts sent in response to it, can be null

data the parameter of the execute operation, can be null

- Execute the given node with the given data. This operation corresponds to the EXEC command in OMA DM.

  The semantics of an execute operation and the data parameter it takes depends on the definition of the managed object on which the command is issued. Session information is given as it is needed for sending alerts back from the plugin. If a correlation ID is specified, it should be used as the correlator parameter for alerts sent in response to this execute operation.

The nodePath parameter contains an array of path segments identifying the node to be executed in the subtree of this plugin. This is an absolute path, so the first segment is always ".". Special characters appear escaped in the segments.

Throws DmtException – with the following possible error codes:
NODE_NOT_FOUND if the node does not exist and the plugin does not allow executing unexisting nodes
METADATA_MISMATCH if the command failed because of meta-data restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

See Also DmtSession.execute(String, String), DmtSession.execute(String, String, String)

117.14.4 public interface ReadableDataSession

Provides read-only access to the part of the tree handled by the plugin that created this session.

Since the ReadWriteDataSession[p.407] and TransactionalDataSession[p.412] interfaces inherit from this interface, some of the method descriptions do not apply for an instance that is only a ReadableDataSession. For example, the close[p.403] method description also contains information about its behaviour when invoked as part of a transactional session.

The nodePath parameters appearing in this interface always contain an array of path segments identifying a node in the subtree of this plugin. This parameter contains an absolute path, so the first segment is always ".". Special characters appear escaped in the segments.

Error handling

When a tree access command is called on the DmtAdmin service, it must perform an extensive set of checks on the parameters and the authority of the caller before delegating the call to a plugin. Therefore plugins can take certain circumstances for granted: that the path is valid and is within the subtree of the plugin and the session, the command can be applied to the given node (e.g. the target of getChildNodeNames is an interior node), etc. All errors described by the error codes DmtException.INVALID_URI, DmtException.URI_TOO_LONG, DmtException.PERMISSION_DENIED, DmtException.COMMAND_NOT_ALLOWED and DmtException.TRANSACTION_ERROR are fully filtered out before control reaches the plugin.

If the plugin provides meta-data for a node, the DmtAdmin service must also check the constraints specified by it, as described in MetaNode. If the plugin does not provide meta-data, it must perform the necessary checks for itself and use the DmtException.METADATA_MISMATCH error code to indicate such discrepancies.

The DmtAdmin also ensures that the targeted nodes exist before calling the plugin (except, of course, before the isNodeUri call). However, some small amount of time elapses between the check and the call, so in case of plugins where the node structure can change independantly from the DMT, the target node might disappear in that time. For example, a whole subtree can disappear when a Monitorable application is unregistered, which might happen in the middle of a DMT session accessing it. Plugins managing such nodes always need to check whether they still exist and throw DmtException.NODE_NOT_FOUND as necessary, but for more static subtrees there is no need for the plugin to use this error code.

The plugin can use the remaining error codes as needed. If an error does not fit into any other category, the DmtException.COMMAND_FAILED code should be used.

117.14.4.1 public void close( ) throws DmtException

- Closes a session. This method is always called when the session ends for any reason: if the session is closed, if a fatal error occurs in any method, or if any error occurs during commit or rollback. In case the session was invalidated due to an exception during commit or rollback, it is guaranteed that no methods are called on the plugin until it is closed. In case the session was invalidated due to a fatal exception in one of the tree manipulation methods, only the rollback method is called before this (and only in atomic sessions).

  This method should not perform any data manipulation, only cleanup operations. In non-atomic read-write sessions the data manipulation should be done instantly during each tree operation, while in atomic sessions the DmtAdmin always calls TransactionalDataSession.commit[p.412] automatically before the session is actually closed.

Throws DmtException – with the error code COMMAND_FAILED if the plugin failed to close for any reason

117.14.4.2 public String[] getChildNodeNames(String[] nodePath) throws DmtException

nodePath the absolute path of the node

- Get the list of children names of a node. The returned array contains the names - not the URIs - of the immediate children nodes of the given node. The returned child names must be mangled (info.dmtree.Uri.mangle). The returned array may contain null entries, but these are removed by the DmtAdmin before returning it to the client.

Returns the list of child node names as a string array or an empty string array if the node has no children

Throws DmtException – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the information could not be retrieved because of meta-data restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.4.3 public MetaNode getMetaNode(String[] nodePath) throws DmtException

nodePath the absolute path of the node

- Get the meta data which describes a given node. Meta data can be only inspected, it can not be changed.

  Meta data support by plugins is an optional feature. It can be used, for example, when a data plugin is implemented on top of a data store or another API that has their own metadata, such as a relational database, in order to avoid metadata duplication and inconsistency. The meta data specific to the plugin returned by this method is complemented by meta data from the DmtAdmin before returning it to the client. If there are differences in the meta data elements known by the plugin and the DmtAdmin then the plugin specific elements take precedence.

  Note, that a node does not have to exist for having meta-data associated with it. This method may provide meta-data for any node that can possibly exist in the tree (any node defined by the Management Object provided by the plugin). For nodes that are not defined, a DmtException may be thrown with the NODE_NOT_FOUND error code. To allow easier implementation of plugins that do not provide meta-data, it is allowed to return null for any node, regardless of whether it is defined or not.

Returns a MetaNode which describes meta data information, can be null if there is no meta data available for the given node

Throws DmtException – with the following possible error codes:
NODE_NOT_FOUND if nodeUri points to a node that is not defined in the tree (see above)
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.4.4 public int getNodeSize(String[] nodePath) throws DmtException

nodePath the absolute path of the leaf node

- Get the size of the data in a leaf node. The value to return depends on the format of the data in the node, see the description of the DmtData.getSize() method for the definition of node size for each format.

Returns the size of the data in the node

Throws DmtException – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the information could not be retrieved because of meta-data restrictions
FEATURE_NOT_SUPPORTED if the Size property is not supported by the plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store

COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

See Also `DmtData.getSize`

117.14.4.5 public Date getNodeTimestamp(String[] nodePath) throws DmtException

nodePath the absolute path of the node

- Get the timestamp when the node was last modified.

Returns the timestamp of the last modification

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the information could not be retrieved because of meta-data restrictions
FEATURE_NOT_SUPPORTED if the Timestamp property is not supported by the plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.4.6 public String getNodeTitle(String[] nodePath) throws DmtException

nodePath the absolute path of the node

- Get the title of a node. There might be no title property set for a node.

Returns the title of the node, or null if the node has no title

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the information could not be retrieved because of meta-data restrictions
FEATURE_NOT_SUPPORTED if the Title property is not supported by the plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.4.7 public String getNodeType(String[] nodePath) throws DmtException

nodePath the absolute path of the node

- Get the type of a node. The type of leaf node is the MIME type of the data it contains. The type of an interior node is a URI identifying a DDF document; a null type means that there is no DDF document overriding the tree structure defined by the ancestors.

Returns the type of the node, can be null

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the information could not be retrieved because of meta-data restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.4.8 public DmtData getNodeValue(String[] nodePath) throws DmtException

nodePath the absolute path of the node to retrieve

□ Get the data contained in a leaf or interior node.

Returns the data of the leaf node, must not be null

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the information could not be retrieved because of meta-data restrictions
FEATURE_NOT_SUPPORTED if the specified node is an interior node and does not support Java object values
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.4.9 public int getNodeVersion(String[] nodePath) throws DmtException

nodePath the absolute path of the node

□ Get the version of a node. The version can not be set, it is calculated automatically by the device. It is incremented modulo 0x10000 at every modification of the value or any other property of the node, for both leaf and interior nodes. When a node is created the initial value is 0.

Returns the version of the node

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the information could not be retrieved because of meta-data restrictions
FEATURE_NOT_SUPPORTED if the Version property is not supported by the plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.4.10 public boolean isLeafNode(String[] nodePath) throws DmtException

nodePath the absolute path of the node

- Tells whether a node is a leaf or an interior node of the DMT.

Returns true if the given node is a leaf node

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the information could not be retrieved because of meta-data restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.4.11 public boolean isNodeUri(String[] nodePath)

nodePath the absolute path to check

- Check whether the specified path corresponds to a valid node in the DMT.

Returns true if the given node exists in the DMT

117.14.4.12 public void nodeChanged(String[] nodePath) throws DmtException

nodePath the absolute path of the node that has changed

- Notifies the plugin that the given node has changed outside the scope of the plugin, therefore the Version and Timestamp properties must be updated (if supported). This method is needed because the ACL property of a node is managed by the DmtAdmin instead of the plugin. The DmtAdmin must call this method whenever the ACL property of a node changes.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

117.14.5 public interface ReadWriteDataSession extends ReadableDataSession

Provides non-atomic read-write access to the part of the tree handled by the plugin that created this session.

The nodePath parameters appearing in this interface always contain an array of path segments identifying a node in the subtree of this plugin. This parameter contains an absolute path, so the first segment is always ".". Special characters appear escaped in the segments.

Error handling

When a tree manipulation command is called on the DmtAdmin service, it must perform an extensive set of checks on the parameters and the authority of the caller before delegating the call to a plugin. Therefore plugins can take certain circumstances for granted: that the path is valid and is within the subtree of the plugin and the session, the command can be applied to the given node (e.g. the target of setNodeValue is a leaf node), etc. All errors described by the error codes DmtException.INVALID_URI, DmtExcep-

tion.URI_TOO_LONG, DmtException.PERMISSION_DENIED, DmtException.COMMAND_NOT_ALLOWED and DmtException.TRANSACTION_ERROR are fully filtered out before control reaches the plugin.

If the plugin provides meta-data for a node, the DmtAdmin service must also check the constraints specified by it, as described in MetaNode. If the plugin does not provide meta-data, it must perform the necessary checks for itself and use the DmtException.METADATA_MISMATCH error code to indicate such discrepancies.

The DmtAdmin also ensures that the targeted nodes exist before calling the plugin (or that they do not exist, in case of node creation). However, some small amount of time elapses between the check and the call, so in case of plugins where the node structure can change independantly from the DMT, the target node might appear/disappear in that time. For example, a whole subtree can disappear when a Monitorable application is unregistered, which might happen in the middle of a DMT session accessing it. Plugins managing such nodes always need to check the existance or non-existance of nodes and throw DmtException.NODE_NOT_FOUND or DmtException.NODE_ALREADY_EXISTS as necessary, but for more static subtrees there is no need for the plugin to use these error codes.

The plugin can use the remaining error codes as needed. If an error does not fit into any other category, the DmtException.COMMAND_FAILED code should be used.

117.14.5.1 public void copy(String[] nodePath, String[] newNodePath, boolean recursive) throws DmtException

nodePath an absolute path specifying the node or the root of a subtree to be copied

newNodePath the absolute path of the new node or root of a subtree

recursive false if only a single node is copied, true if the whole subtree is copied

□ Create a copy of a node or a whole subtree. Beside the structure and values of the nodes, most properties managed by the plugin must also be copied, with the exception of the Timestamp and Version properties.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node, or if newNodePath points to a node that cannot exist in the tree
NODE_ALREADY_EXISTS if newNodePath points to a node that already exists
METADATA_MISMATCH if the node could not be copied because of meta-data restrictions
FEATURE_NOT_SUPPORTED if the copy operation is not supported by the plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

See Also `DmtSession.copy(String, String, boolean)`

117.14.5.2 public void createInteriorNode(String[] nodePath, String type) throws DmtException

nodePath the absolute path of the node to create

type the type URI of the interior node, can be null if no node type is defined

- Create an interior node with a given type. The type of interior node, if specified, is a URI identifying a DDF document.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a node that cannot exist in the tree
NODE_ALREADY_EXISTS if nodeUri points to a node that already exists
METADATA_MISMATCH if the node could not be created because of metadata restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

See Also `DmtSession.createInteriorNode(String)`, `DmtSession.createInteriorNode(String, String)`

117.14.5.3 public void createLeafNode(String[] nodePath, DmtData value, String mimeType) throws DmtException

nodePath the absolute path of the node to create

value the value to be given to the new node, can be null

mimeType the MIME type to be given to the new node, can be null

- Create a leaf node with a given value and MIME type. If the specified value or MIME type is null, their default values must be taken.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a node that cannot exist in the tree
NODE_ALREADY_EXISTS if nodePath points to a node that already exists
METADATA_MISMATCH if the node could not be created because of metadata restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

See Also `DmtSession.createLeafNode(String)`, `DmtSession.createLeafNode(String, DmtData)`, `DmtSession.createLeafNode(String, DmtData, String)`

117.14.5.4 public void deleteNode(String[] nodePath) throws DmtException

nodePath the absolute path of the node to delete

- Delete the given node. Deleting interior nodes is recursive, the whole subtree under the given node is deleted.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the node could not be deleted because of meta-data restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

See Also `DmtSession.deleteNode(String)`

117.14.5.5 public void renameNode(String[] nodePath, String newName) throws DmtException

nodePath the absolute path of the node to rename

newName the new name property of the node

- Rename a node. This operation only changes the name of the node (updating the timestamp and version properties if they are supported), the value and the other properties are not changed. The new name of the node must be provided, the new path is constructed from the base of the old path and the given name.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node, or if the new node is not defined in the tree
NODE_ALREADY_EXISTS if there already exists a sibling of nodePath with the name newName
METADATA_MISMATCH if the node could not be renamed because of meta-data restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

See Also `DmtSession.renameNode(String, String)`

117.14.5.6 public void setNodeTitle(String[] nodePath, String title) throws DmtException

nodePath the absolute path of the node

title the title text of the node, can be null

- Set the title property of a node. The length of the title is guaranteed not to exceed the limit of 255 bytes in UTF-8 encoding.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the title could not be set because of meta-data restrictions
FEATURE_NOT_SUPPORTED if the Title property is not supported by the plugin
DATA_STORE_FAILURE if an error occurred while accessing the data store

COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

See Also `DmtSession.setNodeTitle(String, String)`

117.14.5.7 public void setNodeType(String[] nodePath, String type) throws DmtException

nodePath the absolute path of the node

type the type of the node, can be null

- Set the type of a node. The type of leaf node is the MIME type of the data it contains. The type of an interior node is a URI identifying a DDF document.

  For interior nodes, the null type should remove the reference (if any) to a DDF document overriding the tree structure defined by the ancestors. For leaf nodes, it requests that the default MIME type is used for the given node.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the type could not be set because of meta-data restrictions
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

`SecurityException` – if the caller does not have the necessary permissions to execute the underlying management operation

See Also `DmtSession.setNodeType(String, String)`

117.14.5.8 public void setNodeValue(String[] nodePath, DmtData data) throws DmtException

nodePath the absolute path of the node

data the data to be set, can be null

- Set the value of a leaf or interior node. The format of the node is contained in the DmtData object. For interior nodes, the format is FORMAT_NODE, while for leaf nodes this format is never used.

  If the specified value is null, the default value must be taken; if there is no default value, a DmtException with error code METADATA_MISMATCH must be thrown.

Throws `DmtException` – with the following possible error codes:
NODE_NOT_FOUND if nodePath points to a non-existing node
METADATA_MISMATCH if the value could not be set because of meta-data restrictions
FEATURE_NOT_SUPPORTED if the specified node is an interior node and does not support Java object values
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation

See Also DmtSession.setNodeValue(String, DmtData)

117.14.6 public interface TransactionalDataSession extends ReadWriteDataSession

Provides atomic read-write access to the part of the tree handled by the plugin that created this session.

117.14.6.1 public void commit( ) throws DmtException

- Commits a series of DMT operations issued in the current atomic session since the last transaction boundary. Transaction boundaries are the creation of this object that starts the session, and all subsequent commit[p.412] and rollback[p.412] calls.

  This method can fail even if all operations were successful. This can happen due to some multi-node semantic constraints defined by a specific implementation. For example, node A can be required to always have children A/B, A/C and A/D. If this condition is broken when commit() is executed, the method will fail, and throw a METADATA_MISMATCH exception.

  In many cases the tree is not the only way to manage a given part of the system. It may happen that while modifying some nodes in an atomic session, the underlying settings are modified parallelly outside the scope of the DMT. If this is detected during commit, an exception with the code CONCURRENT_ACCESS is thrown.

Throws DmtException – with the following possible error codes
METADATA_MISMATCH if the operation failed because of meta-data restrictions
CONCURRENT_ACCESS if it is detected that some modification has been made outside the scope of the DMT to the nodes affected in the session's operations
DATA_STORE_FAILURE if an error occurred while accessing the data store
COMMAND_FAILED if some unspecified error is encountered while attempting to complete the command

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation

117.14.6.2 public void rollback( ) throws DmtException

- Rolls back a series of DMT operations issued in the current atomic session since the last transaction boundary. Transaction boundaries are the creation of this object that starts the session, and all subsequent commit[p.412] and rollback[p.412] calls.

Throws DmtException – with the error code ROLLBACK_FAILED in case the rollback did not succeed

SecurityException – if the caller does not have the necessary permissions to execute the underlying management operation

117.15 info.dmtree.notification

Device Management Tree Notification Package Version 1.0. This package contains the public API of the Notification service. This service enables the sending of asynchronous notifications to management servers. Permission classes are provided by the info.dmtree.security package.

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

```
Import-Package: info.dmtree.notification;version=1.0
```

117.15.1 Summary

- AlertItem - Immutable data structure carried in an alert (client initiated notification). [p.413]
- NotificationService - NotificationService enables sending aynchronous notifications to a management server. [p.415]

117.15.2 public class AlertItem

Immutable data structure carried in an alert (client initiated notification). The AlertItem describes details of various notifications that can be sent by the client, for example as alerts in the OMA DM protocol. The use cases include the client sending a session request to the server (alert 1201), the client notifying the server of completion of a software update operation (alert 1226) or sending back results in response to an asynchronous EXEC command.

The data syntax and semantics varies widely between various alerts, so does the optionality of particular parameters of an alert item. If an item, such as source or type, is not defined, the corresponding getter method returns null. For example, for alert 1201 (client-initiated session) all elements will be null.

The syntax used in AlertItem class corresponds to the OMA DM alert format. NotificationService[p.415] implementations on other management protocols should map these constructs to the underlying protocol.

117.15.2.1 public AlertItem(String source, String type, String mark, DmtData data)

source the URI of the node which is the source of the alert item

type a MIME type or a URN that identifies the type of the data in the alert item

data a DmtData object that contains the format and value of the data in the alert item

mark the mark parameter of the alert item

□ Create an instance of the alert item. The constructor takes all possible data entries as parameters. Any of these parameters can be null. The semantics of the parameters may be refined by the definition of a specific alert, identified by its alert code (see NotificationService.sendNotification[p.415]). In case of Generic Alerts for example (code 1226), the mark parameter contains a severity string.

117.15.2.2 public AlertItem(String[] source, String type, String mark, DmtData data)

source the path of the node which is the source of the alert item

type a MIME type or a URN that identifies the type of the data in the alert item

data a DmtData object that contains the format and value of the data in the alert item

mark the mark parameter of the alert item

- Create an instance of the alert item, specifying the source node URI as an array of path segments. The constructor takes all possible data entries as parameters. Any of these parameters can be null. The semantics of the parameters may be refined by the definition of a specific alert, identified by its alert code (see NotificationService.sendNotification[p.415]). In case of Generic Alerts for example (code 1226), the mark parameter contains a severity string.

117.15.2.3 public DmtData getData( )

- Get the data associated with the alert item. The returned DmtData object contains the format and the value of the data in the alert item. There might be no data associated with the alert item.

Returns the data associated with the alert item, or null if there is no data

117.15.2.4 public String getMark( )

- Get the mark parameter associated with the alert item. The interpretation of the mark parameter depends on the alert being sent, as identified by the alert code in NotificationService.sendNotification[p.415] . There might be no mark associated with the alert item.

Returns the mark associated with the alert item, or null if there is no mark

117.15.2.5 public String getSource( )

- Get the node which is the source of the alert. There might be no source associated with the alert item.

Returns the URI of the node which is the source of this alert, or null if there is no source

117.15.2.6 public String getType( )

- Get the type associated with the alert item. The type string is a MIME type or a URN that identifies the type of the data in the alert item (returned by getData[p.414]). There might be no type associated with the alert item.

Returns the type type associated with the alert item, or null if there is no type

117.15.2.7 public String toString( )

- Returns the string representation of this alert item. The returned string includes all parameters of the alert item, and has the following format:

  ```
  AlertItem(<source>, <type>, <mark>, <data>)
  ```

  The last parameter is the string representation of the data value. The format of the data is not explicitly included.

Returns the string representation of this alert item

117.15.3 public interface NotificationService

NotificationService enables sending aynchronous notifications to a management server. The implementation of NotificationService should register itself in the OSGi service registry as a service.

117.15.3.1 public void sendNotification(String principal, int code, String correlator, AlertItem[] items) throws DmtException

principal the principal name which is the recipient of this notification, can be null

code the alert code, can be 0 if not needed

correlator optional field that contains the correlation identifier of an associated exec command, can be null if not needed

items the data of the alert items carried in this alert, can be null or empty if not needed

- Sends a notification to a named principal. It is the responsibility of the NotificationService to route the notification to the given principal using the registered info.dmtree.notification.spi.RemoteAlertSender services.

  In remotely initiated sessions the principal name identifies the remote server that created the session, this can be obtained using the session's DmtSession.getPrincipal getPrincipal call.

  The principal name may be omitted if the client does not know the principal name. Even in this case the routing might be possible if the Notification Service finds an appropriate default destination (for example if it is only connected to one protocol adapter, which is only connected to one management server).

  Since sending the notification and receiving acknowledgment for it is potentially a very time-consuming operation, notifications are sent asynchronously. This method should attempt to ensure that the notification can be sent successfully, and should throw an exception if it detects any problems. If the method returns without error, the notification is accepted for sending and the implementation must make a best-effort attempt to deliver it.

  In case the notification is an asynchronous response to a previous DmtSession.execute(String, String, String) execute command, a correlation identifier can be specified to provide the association between the execute and the notification.

  In order to send a notification using this method, the caller must have an AlertPermission with a target string matching the specified principal name. If the principal parameter is null (the principal name is not known), the target of the AlertPermission must be "*".

  When this method is called with all its parameters null or 0 (except principal), it should send a protocol specific default notification to initiate a management session. For example, in case of OMA DM this is alert 1201 "Client Initiated Session". The principal parameter can be used to determine the recipient of the session initiation request.

Throws `DmtException` – with the following possible error codes:
UNAUTHORIZED when the remote server rejected the request due to insufficient authorization
ALERT_NOT_ROUTED when the alert can not be routed to the given principal
REMOTE_ERROR in case of communication problems between the device and the destination
COMMAND_FAILED for unspecified errors encountered while attempting to complete the command
FEATURE_NOT_SUPPORTED if the underlying management protocol doesn't support asynchronous notifications

`SecurityException` – if the caller does not have the required AlertPermission with a target matching the principal parameter, as described above

117.16 info.dmtree.notification.spi

Device Management Tree Notification SPI Package Version 1.0. This package contains the SPI (Service Provider Interface) of the Notification service. These interfaces are implemented by Protocol Adapters capable of delivering notifications to management servers on a specific protocol. Users of the NotificationService interface do not interact directly with this package.

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

```
Import-Package: info.dmtree.notification.spi;version=1.0
```

117.16.1 public interface RemoteAlertSender

The RemoteAlertSender can be used to send notifications to (remote) entities identified by principal names. This service is provided by Protocol Adapters, and is used by the info.dmtree.notification.NotificationService when sending alerts. Implementations of this interface have to be able to connect and send alerts to one or more management servers in a protocol specific way.

The properties of the service registration should specify a list of destinations (principals) where the service is capable of sending alerts. This can be done by providing a String array of principal names in the principals registration property. If this property is not registered, the service will be treated as the default sender. The default alert sender is only used when a more specific alert sender cannot be found.

The principals registration property is used when the info.dmtree.notification.NotificationService.sendNotification method is called, to find the proper RemoteAlertSender for the given destination. If the caller does not specify a principal, the alert is only sent if the Notification Sender finds a default alert sender, or if the choice is unambiguous for some other reason (for example if only one alert sender is registered).

117.16.1.1 public void sendAlert(String principal, int code, String correlator,

AlertItem[] items) throws Exception

principal the name identifying the server where the alert should be sent, can be null

code the alert code, can be 0 if not needed

correlator the correlation identifier of an associated EXEC command, or null if there is no associated EXEC

items the data of the alert items carried in this alert, can be empty or null if no alert items are needed

- Sends an alert to a server identified by its principal name. In case the alert is sent in response to a previous info.dmtree.DmtSession.execute(String, String, String) execute command, a correlation identifier can be specified to provide the association between the execute and the alert.

  The principal parameter specifies which server the alert should be sent to. This parameter can be null if the client does not know the name of the destination. The alert should still be delivered if possible; for example if the alert sender is only connected to one destination.

  Any exception thrown on this method will be propagated to the original sender of the event, wrapped in a DmtException with the code REMOTE_ERROR.

  Since sending the alert and receiving acknowledgment for it is potentially a very time-consuming operation, alerts are sent asynchronously. This method should attempt to ensure that the alert can be sent successfully, and should throw an exception if it detects any problems. If the method returns without error, the alert is accepted for sending and the implementation must make a best-effort attempt to deliver it.

Throws Exception – if the alert can not be sent to the server

117.17 info.dmtree.registry

Device Management Tree Registry Package Version 1.0. This package contains the factory class providing access to the different Device Management services for non-OSGi applications. The DmtServiceFactory class contained in this package provides methods for retrieving NotificationService and DmtAdmin service implementations.

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

```
Import-Package: info.dmtree.registry;version=1.0
```

117.17.1 public final class DmtServiceFactory

This class is the central access point for Device Management services. Applications can use the static factory methods provided in this class to obtain access to the different Device Management related services, such as the DmtAdmin for manipulating the tree, or the Notification Service for sending notifications to management servers.

These methods are not needed in an OSGi environment, clients should retrieve the required service objects from the OSGi Service Registry.

117.17.1.1 public static DmtAdmin getDmtAdmin( )

- This method is used to obtain access to DmtAdmin, which enables applications to manipulate the Device Management Tree.

Returns a DmtAdmin service object

117.17.1.2 public static NotificationService getNotificationService( )

- This method is used to obtain access to NotificationService, which enables applications to send asynchronous notifications to management servers.

Returns a NotificationService service object

117.18 info.dmtree.security

Device Management Tree Security Package Version 1.0. This package contains the permission classes used by the Device Management API in environments that support the Java 2 security model.

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

```
Import-Package: info.dmtree.security;version=1.0
```

117.18.1 Summary

- AlertPermission - Indicates the callers authority to send alerts to management servers, identified by their principal names. [p.418]
- DmtPermission - Controls access to management objects in the Device Management Tree (DMT). [p.419]
- DmtPrincipalPermission - Indicates the callers authority to create DMT sessions on behalf of a remote management server. [p.422]

117.18.2 public class AlertPermission extends Permission

Indicates the callers authority to send alerts to management servers, identified by their principal names.

AlertPermission has a target string which controls the principal names where alerts can be sent. A wildcard is allowed at the end of the target string, to allow sending alerts to any principal with a name matching the given prefix. The "*" target means that alerts can be sent to any destination.

117.18.2.1 public AlertPermission(String target)

target the name of a principal, can end with * to match any principal identifier with the given prefix

- Creates a new AlertPermission object with its name set to the target string. Name must be non-null and non-empty.

Throws `NullPointerException` – if name is null

IllegalArgumentException – if name is empty

117.18.2.2 public AlertPermission(String target, String actions)

target the name of the server, can end with * to match any server identifier with the given prefix

actions no actions defined, must be "*" for forward compatibility

- Creates a new AlertPermission object using the 'canonical' two argument constructor. In this version this class does not define any actions, the second argument of this constructor must be "*" so that this class can later be extended in a backward compatible way.

Throws NullPointerException – if name or actions is null

IllegalArgumentException – if name is empty or actions is not "*"

117.18.2.3 public boolean equals(Object obj)

obj the object to compare to this AlertPermission instance

- Checks whether the given object is equal to this AlertPermission instance. Two AlertPermission instances are equal if they have the same target string.

Returns true if the parameter represents the same permissions as this instance

117.18.2.4 public String getActions( )

- Returns the action list (always * in the current version).

Returns the action string "*"

117.18.2.5 public int hashCode( )

- Returns the hash code for this permission object. If two AlertPermission objects are equal according to the equals[p.419] method, then calling this method on each of the two AlertPermission objects must produce the same integer result.

Returns hash code for this permission object

117.18.2.6 public boolean implies(Permission p)

p the permission to check for implication

- Checks if this AlertPermission object implies the specified permission. Another AlertPermission instance is implied by this permission either if the target strings are identical, or if this target can be made identical to the other target by replacing a trailing "*" with any string.

Returns true if this AlertPermission instance implies the specified permission

117.18.2.7 public PermissionCollection newPermissionCollection( )

- Returns a new PermissionCollection object for storing AlertPermission objects.

Returns the new PermissionCollection

117.18.3 public class DmtPermission extends Permission

Controls access to management objects in the Device Management Tree (DMT). It is intended to control local access to the DMT. DmtPermission target string identifies the management object URI and the action field lists the OMA DM commands that are permitted on the management object. Example:

```
DmtPermission(". /OSGi/bundles", "Add,Replace,Get");
```

This means that owner of this permission can execute Add, Replace and Get commands on the ./OSGi/bundles management object. It is possible to use wildcards in both the target and the actions field. Wildcard in the target field means that the owner of the permission can access children nodes of the target node. Example:

```
DmtPermission(". /OSGi/bundles/*", "Get");
```

This means that owner of this permission has Get access on every child node of ./OSGi/bundles. The asterix does not necessarily have to follow a '/' character. For example the "./OSGi/a*" target matches the ./OSGi/applications subtree.

If wildcard is present in the actions field, all legal OMA DM commands are allowed on the designated nodes(s) by the owner of the permission. Action names are interpreted case-insensitively, but the canonical action string returned by `getActions`[p.421] uses the forms defined by the action constants.

117.18.3.1 public static final String ADD = "Add"

Holders of DmtPermission with the Add action present can create new nodes in the DMT, that is they are authorized to execute the createInteriorNode() and createLeafNode() methods of the DmtSession. This action is also required for the copy() command, which needs to perform node creation operations (among others).

117.18.3.2 public static final String DELETE = "Delete"

Holders of DmtPermission with the Delete action present can delete nodes from the DMT, that is they are authorized to execute the deleteNode() method of the DmtSession.

117.18.3.3 public static final String EXEC = "Exec"

Holders of DmtPermission with the Exec action present can execute nodes in the DMT, that is they are authorized to call the execute() method of the DmtSession.

117.18.3.4 public static final String GET = "Get"

Holders of DmtPermission with the Get action present can query DMT node value or properties, that is they are authorized to execute the isLeafNode(), getNodeAcl(), getEffectiveNodeAcl(), getMetaNode(), getNodeValue(), getChildNodeNames(), getNodeTitle(), getNodeVersion(), getNodeTimeStamp(), getNodeSize() and getNodeType() methods of the DmtSession. This action is also required for the copy() command, which needs to perform node query operations (among others).

117.18.3.5 public static final String REPLACE = "Replace"

Holders of DmtPermission with the Replace action present can update DMT node value or properties, that is they are authorized to execute the setNodeAcl(), setNodeTitle(), setNodeValue(), setNodeType() and renameNode() methods of the DmtSession. This action is also be required for the copy() command if the original node had a title property (which must be set in the new node).

117.18.3.6 public DmtPermission(String dmtUri, String actions)

dmtUri URI of the management object (or subtree)

actions OMA DM actions allowed

□ Creates a new DmtPermission object for the specified DMT URI with the specified actions. The given URI can be:

- "*", which matches all valid (see Uri.isValidUri) absolute URIs;
- the prefix of an absolute URI followed by the * character (for example "./OSGi/L*"), which matches all valid absolute URIs beginning with the given prefix;
- a valid absolute URI, which matches itself.

Since the * character is itself a valid URI character, it can appear as the last character of a valid absolute URI. To distinguish this case from using * as a wildcard, the * character at the end of the URI must be escaped with the \ charater. For example the URI "./a*" matches "./a", "./aa", "./a/b" etc. while "./a*" matches "./a*" only.

The actions string must either be "*" to allow all actions, or it must contain a non-empty subset of the valid actions, defined as constants in this class.

Throws `NullPointerException` – if any of the parameters are null

`IllegalArgumentException` – if any of the parameters are invalid

117.18.3.7 public boolean equals(Object obj)

obj the object to compare to this DmtPermission instance

□ Checks whether the given object is equal to this DmtPermission instance. Two DmtPermission instances are equal if they have the same target string and the same action mask. The "*" action mask is considered equal to a mask containing all actions.

Returns true if the parameter represents the same permissions as this instance

117.18.3.8 public String getActions( )

- Returns the String representation of the action list. The allowed actions are listed in the following order: Add, Delete, Exec, Get, Replace. The wildcard character is not used in the returned string, even if the class was created using the "*" wildcard.

Returns canonical action list for this permission object

117.18.3.9 public int hashCode( )

- Returns the hash code for this permission object. If two DmtPermission objects are equal according to the `equals`[p.421] method, then calling this method on each of the two DmtPermission objects must produce the same integer result.

Returns hash code for this permission object

117.18.3.10 public boolean implies(Permission p)

p the permission to check for implication

- Checks if this DmtPermission object "implies" the specified permission. This method returns false if and only if at least one of the following conditions are fulfilled for the specified permission:
  - it is not a DmtPermission
  - its set of actions contains an action not allowed by this permission
  - the set of nodes defined by its path contains a node not defined by the path of this permission

Returns true if this DmtPermission instance implies the specified permission

117.18.3.11 public PermissionCollection newPermissionCollection( )

- Returns a new PermissionCollection object for storing DmtPermission objects.

Returns the new PermissionCollection

117.18.4 public class DmtPrincipalPermission extends Permission

Indicates the callers authority to create DMT sessions on behalf of a remote management server. Only protocol adapters communicating with management servers should be granted this permission.

DmtPrincipalPermission has a target string which controls the name of the principal on whose behalf the protocol adapter can act. A wildcard is allowed at the end of the target string, to allow using any principal name with the given prefix. The "*" target means the adapter can create a session in the name of any principal.

117.18.4.1 public DmtPrincipalPermission(String target)

target the name of the principal, can end with * to match any principal with the given prefix

- Creates a new DmtPrincipalPermission object with its name set to the target string. Name must be non-null and non-empty.

Throws `NullPointerException` – if name is null

`IllegalArgumentException` – if name is empty

117.18.4.2 public DmtPrincipalPermission(String target, String actions)

target the name of the principal, can end with ∗ to match any principal with the given prefix

actions no actions defined, must be "∗" for forward compatibility

□ Creates a new DmtPrincipalPermission object using the 'canonical' two argument constructor. In this version this class does not define any actions, the second argument of this constructor must be "∗" so that this class can later be extended in a backward compatible way.

Throws `NullPointerException` – if name or actions is null

`IllegalArgumentException` – if name is empty or actions is not "∗"

117.18.4.3 public boolean equals(Object obj)

obj the object to compare to this DmtPrincipalPermission instance

□ Checks whether the given object is equal to this DmtPrincipalPermission instance. Two DmtPrincipalPermission instances are equal if they have the same target string.

Returns true if the parameter represents the same permissions as this instance

117.18.4.4 public String getActions( )

□ Returns the action list (always ∗ in the current version).

Returns the action string "∗"

117.18.4.5 public int hashCode( )

□ Returns the hash code for this permission object. If two DmtPrincipalPermission objects are equal according to the `equals`[p.423] method, then calling this method on each of the two DmtPrincipalPermission objects must produce the same integer result.

Returns hash code for this permission object

117.18.4.6 public boolean implies(Permission p)

p the permission to check for implication

□ Checks if this DmtPrincipalPermission object implies the specified permission. Another DmtPrincipalPermission instance is implied by this permission either if the target strings are identical, or if this target can be made identical to the other target by replacing a trailing "∗" with any string.

Returns true if this DmtPrincipalPermission instance implies the specified permission

117.18.4.7 public PermissionCollection newPermissionCollection( )

□ Returns a new PermissionCollection object for storing DmtPrincipalPermission objects.

Returns the new PermissionCollection

117.19 References

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[2] *OMA DM-RepPro v1.2 draft:*
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[3] *IETF RFC2578. Structure of Management Information*
Version 2 (SMIv2), http://www.ietf.org/rfc/rfc2578.txt

[4] *Java™ Management Extensions Instrumentation and Agent Specification*
v1.2, October 2002, http://java.sun.com/products/JavaManagement/

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118 Mobile Conditions Specification

Version 1.0

118.1 Introduction

This section defines a number of conditions that are specifically applicable to the mobile world. These conditions can be used with the Conditional Permission Admin service, as specified in *Conditional Permission Admin Specification* on page 205 in the OSGi Core Specification.

118.1.1 Essentials

- *User Prompting Condition* – Allow a set of permissions to depend on the answer of an end user.
- *GSM Equipment Type Condition* – Allow a set of permissions to depend upon the device type on which the code is running, specifically matching a pattern in the GSM International Mobile Equipment Identification (IMEI).
- *GSM Subscriber Condition* – Allow a set of permissions to depend on the subscriber or subscriber group: specifically, the GSM International Mobile Subscriber Identity (IMSI).

118.1.2 Entities

Figure 1 *org.osgi.util.mobile and org.osgi.util.gsm package*

- *IMEI Condition* – A Condition object that is satisfied when the GSM device's IMEI code matches a given pattern.
- *IMSI Condition* – A Condition object that is satisfied when the GSM subscriber's IMSI code matches a given pattern.
- *User Prompt Condition* – A Condition object that is satisfied when the user approves it. Approval can be for the session, one shot, blanket, or never.

118.2 User Prompt Condition

The User Prompt Condition is a condition that allows a set of permissions to depend on interaction with the end user. For example, accessing the Internet can be protected with the following User Prompt Condition:

(

```
    [ org.osgi.util.mobile.UserPromptCondition
      "ONESHOT" "ONESHOT" "com.acme.l10n.Internet",
      "%Internet" ]
    { java.net.SocketPermission "*" "*" }
)
```

The User Prompt Condition is a postponed condition; the actual prompting is delayed until the end of the permission check, so that multiple prompts can be prevented.

The User Prompt Condition can take the following parameters in its ConditionalPermissionInfo object.

- *level* – The level defines how long a given answer can be valid. The user selects one from a given list. The argument is a comma separated list of these levels (case insensitive):
  - ONESHOT – Permission is given once. The user must be prompted every time the isSatisfied method is called with the following choices:
    - *Yes* – Answer true for this occasion
    - *No* – Answer false for this occasion
    - *Never* – Never ask the user again and always return false
  - SESSION – Permission is given for a session. The concept of the session is is left to implementations. A session could be the life time of an application or the length of time the phone is turned on. The first time the isSatisfied method is called in a session, the user must be prompted with at least the following choices:
    - *Yes* – Answer true for the rest of this session.
    - *No* – Answer false for the rest of this session.
    - *Never* – Never ask the user again and always return false until the system is restarted.
  - BLANKET – The permission is given forever, even between system restarts. The first time the isSatisfied method is called for an application, the user must be prompted with at least the following choices:
    - *Always* – Always return true.
    - *Never* – Never returns true.

  At prompting, the implementation can list additional choices, that allow the user to change the current permission level to one of the other possible permission levels. If the application model has applications that span multiple bundles, in a way that the user sees them as one entity, the implementation can ask the question for the whole application.
  The platform implementation should provide a separately launchable management application, where the user can modify the current permission levels for the user prompts. This implies that a UserPrompt is likely never to become immutable.
- *defaultLevel* – The advice to the UI to mark one of the levels as the default.
- *catalog* – The name of a Resource Bundle used for localization. This parameter is given to ResourceBundle getBundle method as the catalog name.
- *prompt* – The text with which to prompt. If this text starts with a percent sign ('%'\u0025), then the name (without the percent sign) must be looked up in the given resource bundle. If the translated name cannot be found, the name (without the percent sign) must be used as translation.

118.2.1 Session Definition

A SESSION is one run of a software from launching to stopping. For applications managed through the Application Admin Service, this should be the time between the call of the ApplicationDescriptor.launch method and the Application.destroymethod, thus the time that one Application Instance is active. Different Application Instances should count as different sessions, even if they overlap.

For other application models, the User Prompt implementation should use a session definition that is closest to the user's perception of one run of the software. If there is no application model for the given bundle, the implementation should use the bundle lifestyle as session definition.

118.3 IMEI Condition

The IMEI Condition can be used to limit permissions to a certain set when the application runs on a specific device. The International Mobile Equipment Identity is an identification number assigned to GSM mobile stations that uniquely identifies each one. It is a 15-digit serial number that contains:

- *type approval code + final assembly code or type allocation code*
- *serial number*

Entering ∗#06# on a GSM phone will show this number.

The IMEI Condition accepts the following parameter:

- *imei* – The 15-digit IMEI or 17-digit IMEISV number. This number must not contain any dashes, but can end with a wildcard ('∗' \u002A).

For example, an operator allows full Admin Permission to a certain phone:

```
(
   [ org.osgi.util.gsm.IMEICondition "35430500∗" ]
   { org.osgi.framework.AdminPermission "∗" "∗" }
)
```

118.4 IMSI Condition

The IMSI Condition can be used to limit permissions to a certain set when the bundle runs on a specific class of devices. The International Mobile Subscriber Identity is an identification number assigned to GSM subscribers. It is a 15-digit serial number that contains:

- *MCC* – mobile country code (3 digits)
- *MNC* – mobile network code (2 or 3 digits)
- *MSIN* – mobile subscriber identification number (9 or 10 digits)

The IMSI Condition accepts the following parameter:

- *imsi* – The 15-digit IMSI number. The number can end with a wildcard ('∗' \u002A) at the end.

For example, an operator allows full Admin Permission to certain phones:

```
(
```

```
    [ org.osgi.util.gsm.IMSICondition "284010927102762" ]
    { org.osgi.framework.AdminPermission "*" "*" }
)
```

118.5 Implementation Issues

The specification contains reference implementations of the condition classes. Implementations of this specification, however, should replace those classes with implementation-specific classes.

The provided classes look for the following system properties:

- org.osgi.util.gsm.imei – The mobile phone's IMEI number.
- org.osgi.util.gsm.imsi – The mobile phone's IMSI number.

Both the provided IMSI and IMEI Conditions check the match when they are constructed with the static getInstance method.

The User Prompt Condition must be a postponed condition so that it can merge multiple prompts. This use case is discussed in several places in the Conditional Permission Admin service specification.

118.6 Security

These condition classes must be provided as Framework extensions.

118.7 org.osgi.util.mobile

Mobile Conditions Package 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.mobile; version=1.0
```

118.7.1 public class UserPromptCondition implements Condition

Class representing a user prompt condition. Instances of this class hold two values: a prompt string that is to be displayed to the user and the permission level string according to MIDP2.0 (oneshot, session, blanket).

118.7.1.1 public static Condition getCondition(Bundle bundle, ConditionInfo conditionInfo)

bundle the bundle to ask about.

conditionInfo the conditionInfo containing the construction information. Its ConditionInfo.getArgs() method should return a String array with 4 strings in it:
the possible permission levels. This is a comma-separated list that can contain following strings: ONESHOT SESSION BLANKET. The order is not important. This parameter is case-insensitive.
the default permission level, one chosen from the possible permission levels. If it is an empty string, then there is no default. This parameter is case-insen-

sitive.
the message catalog base name. It will be loaded by a java.util.ResourceBundle, or equivalent from an exporting OSGi Bundle. Thus, if the catalogName is “com.provider.messages.userprompt”, then there should be an OSGi Bundle exporting the “com.provider.messages” package, and inside it files like “userprompt_en_US.properties”.
textual description of the condition, to be displayed to the user. If it starts with a ‘%’ sign, then the message is looked up from the catalog specified previously. The key is the rest of the string after the ‘%’ sign.

- Returns a UserPromptCondition object with the given prompt string and permission level. The user should be given choice as to what level of permission is given. Thus, the lifetime of the permission is controlled by the user.

Returns The requested UserPromptCondition.

Throws `IllegalArgumentException` – if the parameters are malformed.

`NullPointerException` – if one of the parameters is null.

118.7.1.2 public boolean isMutable( )

- Checks whether the condition may change during the lifetime of the UserPromptCondition object. This depends on the permission level given in `UserPromptCondition.getCondition(Bundle, ConditionInfo)`[p.428].

  - ONESHOT - true
  - SESSION - true, if the application model’s session lifetime is shorter than the UserPromptCondition object lifetime
  - BLANKET - false

  If the system supports separately accessible permission management GUI, then this function may also return true for SESSION and BLANKET.

Returns True, if the condition can change.

118.7.1.3 public boolean isPostponed( )

- Checks if the `isSatisfied()`[p.429] method needs to prompt the user, thus cannot give results instantly. This depends on the permission level given in `UserPromptCondition.getCondition(Bundle, ConditionInfo)`[p.428].

  - ONESHOT - isPostponed always returns true. The user is prompted for question every time.
  - SESSION - isPostponed returns true until the user decides either yes or no for the current session.
  - BLANKET - isPostponed returns true until the user decides either always or never.

  Regardless of the session level, the user is always given the option to reject the prompt permanently, as if BLANKET/never was chosen. In this case, the question is not postponed anymore, and `isSatisfied()`[p.429] returns false.
  If the system supports an separately accessible permission management GUI, that may reset the condition to its initial state.

Returns True, if user interaction is needed.

118.7.1.4 public boolean isSatisfied( )

- Displays the prompt string to the user and returns true if the user accepts. Depending on the amount of levels the condition is assigned to, the prompt may have multiple accept buttons and one of them can be selected by default (see default level parameter at UserPromptCondition.getCondition(Bundle, ConditionInfo)[p.428]). It must always be possible for the user to stop further prompting of this question, even with ONESHOT and SESSION levels. In case of BLANKET and SESSION levels, it is possible that the user has already answered the question, in this case there will be no prompting, but immediate return with the previous answer.

Returns True if the user accepts the prompt (or accepts any prompt in case there are multiple permission levels).

118.7.1.5 public boolean isSatisfied(Condition[] conds, Dictionary context)

conds The array containing the UserPrompt conditions to evaluate.

context Storage area for evaluation. The org.osgi.service.condpermadmin.ConditionalPermissionAdmin may evaluate a condition several times for one permission check, so this context will be used to store results of ONESHOT questions. This way asking the same question twice in a row can be avoided. If context is null, temporary results will not be stored.

- Checks an array of UserPrompt conditions.

Returns True, if all conditions are satisfied.

Throws NullPointerException – if conds is null.

118.8 org.osgi.util.gsm

Mobile GSM Conditions Package 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.gsm; version=1.0
```

118.8.1 Summary

- IMEICondition - Class representing an IMEI condition. [p.430]
- IMSICondition - Class representing an IMSI condition. [p.431]

118.8.2 public class IMEICondition

Class representing an IMEI condition. Instances of this class contain a string value that is matched against the IMEI of the device.

118.8.2.1 public static Condition getCondition(Bundle bundle, ConditionInfo conditionInfo)

bundle ignored, as the IMEI number is the property of the mobile device, and thus the same for all bundles.

conditionInfo contains the IMEI value to match the device's IMEI against. Its ConditionInfo.getArgs() method should return a String array with one value, the IMEI string. The IMEI is 15 digits without hypens. Limited pattern matching is allowed, then the string is 0 to 14 digits, followed by an asterisk(*).

□ Creates an IMEICondition object.

Returns An IMEICondition object, that can tell whether its IMEI number matches that of the device. If the number contains an asterisk(*), then the beginning of the imei is compared to the pattern.

Throws NullPointerException – if one of the parameters is null.

IllegalArgumentException – if the IMEI is not a string of 15 digits, or 0 to 14 digits with an * at the end.

118.8.3 public class IMSICondition

Class representing an IMSI condition. Instances of this class contain a string value that is matched against the IMSI of the subscriber.

118.8.3.1 public static Condition getCondition(Bundle bundle, ConditionInfo conditionInfo)

bundle ignored, as the IMSI number is the same for all bundles.

conditionInfo contains the IMSI value to match the device's IMSI against. Its ConditionInfo.getArgs() method should return a String array with one value, the IMSI string. The IMSI is 15 digits without hypens. Limited pattern matching is allowed, then the string is 0 to 14 digits, followed by an asterisk(*).

□ Creates an IMSI condition object.

Returns An IMSICondition object, that can tell whether its IMSI number matches that of the device. If the number contains an asterisk(*), then the beginning of the IMSI is compared to the pattern.

Throws NullPointerException – if one of the parameters is null.

IllegalArgumentException – if the IMSI is not a string of 15 digits, or 0 to 14 digits with an * at the end.

118.9 References

119 Monitor Admin Service Specification

Version 1.0

119.1 Introduction

Applications and services may publish status information that management systems can receive to monitor the status of the device. For example, a bundle could publish Status Variables for a number key VM variables like the amount of available memory, batter power, number of SMSs sent, etc.

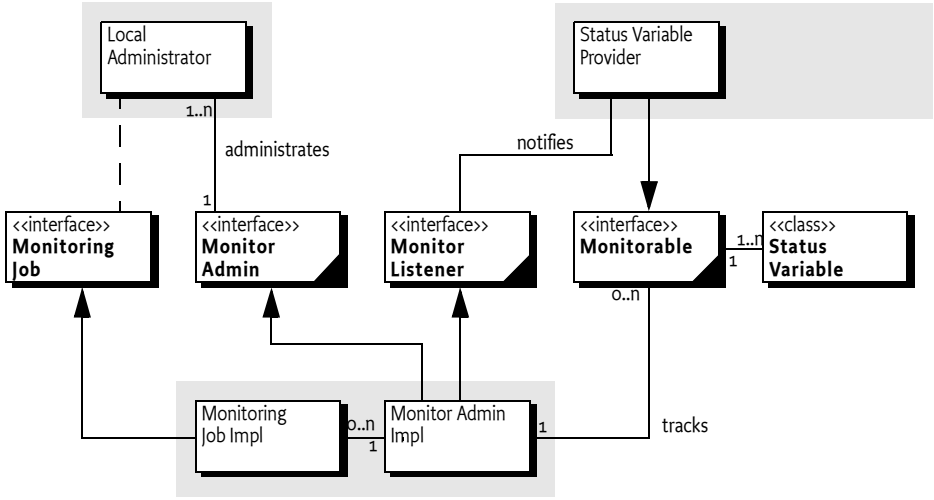
Status Variables can be used in performance management, fault management as well as in customer relations management systems.

This specification outlines how a bundle can publish Status Variables and how administrative bundles can discover Status Variables as well as read and reset their values.

119.1.1 Entities

- *Status Variable* – Application specific variables that a *Status Variable Provider* publishes with a Monitorable service to the Monitor Admin service.Status Variable values can be `long`, `double`, `boolean` or `String` objects.
- *Status Variable Provider* – A bundle which has a number of Status Variables that it publishes with one or more Monitorable services.
- *Monitor Admin* – Provides unified and secure access to available Status Variables as well as providing a function to create monitoring jobs to monitor the Status Variables.
- *Monitorable* – A service that is registered by a Status Variable Provider to publish its Status Variables.
- *Monitor Job* – An event or time based query of a given set of Status Variables. When a monitored Status Variable is updated, or the timer expires, the Monitor Admin must generate an event via the Event Admin service.
- *Local Administrator* – A management application which uses the Monitor Admin service to query Status Variables and to initiate monitoring jobs.
- *Status Variable Name* – The unique name, within a Monitorable service, of a Status Variable.
- *Status Variable Path* – A string that uniquely identifies the Status Variable in an OSGi environment. It consists of the PID of the Monitorable service and the Status Variable name separated by a slash.

Figure 119.1 Monitor Admin Diagram org.osgi.service.monitor package



119.1.2 Synopsis

A bundle that provides a Status Variable must register a Monitorable service. This service is used by the Monitor Admin to get Status Variables and provide meta information to clients.

Clients can use the Monitor Admin to obtain Status Variables in a protected way. Clients can also create Monitoring Jobs. These Monitoring Jobs send out notifications to the clients when the value changes or periodically.

119.2 Monitorable

A Status Variable is a simple scalar that represents some key indicator of the environment, for example amount of available memory. Status Variables are further discussed in *Status Variable* on page 437.

A Status Variable Provider must therefore register a Monitorable service with the service property `service.pid` set to a PID. This PID must have the following format:

```
monitorable-pid ::= symbolic-name          // See 3.2.4 Core
```

The length of this PID must fit in 32 bytes when UTF-8 encoded.

Monitorable services are tracked by the Monitor Admin service. The Monitor Admin service can provide the local administrator unified access to all the Status Variables in the system. This is depicted in Figure 119.2.

Figure 119.2 Access to Status Variables

The main responsibility of a Monitorable service is therefore to provide access to its own Status Variables as well as providing information about those Status Variables.

The Monitorable interface contains the following methods:

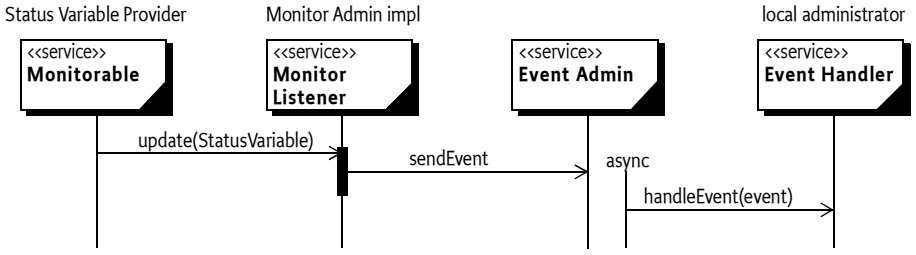
- getStatusVariableNames() – Provides a list of the Status Variable names. The status variables can subsequently be acquired with the getStatus-Variable(String) method.
- getStatusVariable(String) – Given the name of a Status Variable, return the StatusVariable object, if exists.
- resetStatusVariable(String) – Reset the given Status Variable if there is a reasonable reset value. If the Status Variable could not be reset, false is returned. Otherwise true is returned. Resetting a Status Variable triggers a Monitor Event, as described in *Monitoring events* on page 442.
- notifiesOnChange(String) – Tells whether the given Status Variable sends a notification when its value changes or when it is reset. This is further discussed in *Providing Notifications* on page 435.
- getDescription(String) – Provide a non-localized description of the given Status Variable.

119.2.1 Providing Notifications

If a Monitorable service returns true for the notifiesOnChange(String) method then it must notify all Monitor Listener services when the related Status Variable changes. These Status Variables are called *dynamic Status Variables*.

After the value of a dynamic Status Variable is changed, the Monitorable service must get *the singleton* Monitor Listener service and call the updated(String,StatusVariable) method. The Monitor Admin service must use this notification mechanism to send out a generic event via the Event Admin service, as described in *Monitoring events* on page 442. The Monitor Admin can also use this information to signal a remote server in a proprietary way. Figure 119.3 shows a sequence diagram for such an update. This indirection is required for security reasons.

Figure 119.3 Notification on Update



119.2.2 Example Monitorable Implementation

The following code shows how a bundle could provide a Status Variable that contains the current amount of memory.

```
public class MemoryMonitor
```

```
    implements BundleActivator, Monitorable {

    public void start(BundleContext context) {
       Hashtable ht = new Hashtable();
       ht.put("service.pid", "com.acme.foo");
       context.registerService(
          Monitorable.class.getName(), this, ht);
    }

    public void stop(BundleContext context) {}

    public String[] getStatusVariableNames() {
       return new String[] {"memory.free"};
    }

    public StatusVariable getStatusVariable(String name)
       throws IllegalArgumentException {
       if ("memory.free".equals(name))
          return
             new StatusVariable(name,
             StatusVariable.CM_GAUGE,
             Runtime.getRuntime().freeMemory());
       else
          throw new IllegalArgumentException(
             "Invalid Status Variable name " + name);
    }

    public boolean notifiesOnChange(String name)
       throws IllegalArgumentException {
       return false;
    }

    public boolean resetStatusVariable(String name)
       throws IllegalArgumentException {
       return false;
    }

    public String getDescription(String name)
       throws IllegalArgumentException {
        if ("memory.free".equals(name))
          return "current amount of free memory in the JVM";
        else
          throw new IllegalArgumentException(
             "Invalid Status Variable name " + name);
    }
}
```

119.3 Status Variable

A Status Variable is a simple value that is published from a Monitorable service. A Status Variable has a name, a value, a timestamp, and a collection method. Additionally, the Monitorable service that publishes the Status Variable can be used to reset the Status Variable and provide a description of it.

The OSGi Specification provides an implementation class for a Status Variable. This class is final and immutable, it must be treated as a value.

119.3.1 Name

Each Status Variable must have a unique identity in the scope of a Monitorable service. This identity can be obtained with the getID() method. A Status Variable identity must have the following syntax:

```
status-variable-name ::= symbolic-name    // See 3.2.4 Core
```

The name should be descriptive and concise. Additionally, it has the following limitations:

- The length must be limited to 32 characters in UTF-8 encoded form.
- It must be unique in the scope of the Monitorable service.

119.3.2 Value

A Status Variable provides the type of its value with the getType()method. The return value of this method can take the following values:

- TYPE_BOOLEAN – A boolean value. The associated method to retrieve the value is getBoolean(). The corresponding constructor is StatusVariable(String,int,boolean).
- TYPE_INTEGER – A signed numeric value that fits in a Java int type. The associated method to retrieve the value is getInteger(). The corresponding constructor is StatusVariable(String,int,int).
- TYPE_FLOAT – A floating point value that fits in a Java float type. The associated method to retrieve the value is getFloat(). The corresponding constructor is StatusVariable(String,int,float).
- TYPE_STRING – A String object. The associated method to retrieve the value is getString().The corresponding constructor is StatusVariable(String,int,String)

If a method is called that does not match the return value of the getType() method, the Status Variable must throw an Illegal State Exception.

119.3.3 Time Stamp

The time stamp must reflect the time that the measurement was taken from the standard Java System.currentTimeMillis method. The time stamp can be obtained with the getTimeStamp() method.

119.3.4 Collection Method

This specification is compatible with terminology used in [2] *ETSI Performance Management [TS 132 403].* An important concept of a Status Variable is the way it was collected, this is called the *collection method.* The collection method is independent of how (if and when) the reporting of the Status Variables happens. The collection method is part of the Status Variable's definition and cannot be changed. The collection method of a Status Variable can be obtained with the getCollectionMethod() method.

The ETSI document defines the following collection methods:

- CM_CC – A numeric counter whose value can only increase, except when the Status Variable is reset. An example of a CC is a variable which stores the number of incoming SMSs handled by the protocol driver since it was started or reset.
- CM_GAUGE – A numeric counter whose value can vary up or down. An example of a GAUGE is a variable which stores the current battery level percentage. The value of the Status Variable must be the absolute value not a difference.
- CM_DER – (Discrete Event Registration) A status variable (numeric or string) which can change when a certain event happens in the system one or more times. The event which fires the change of the Status Variable is typically some event like the arrival of an SMS. The definition of a DER counter contains an integer N which means how many events it takes for the counter to change its value. The most usual value for N is 1, but if N is greater than 1 then it means that the variable changes after each Nth event.
- - CM_SI – (Status Inspect) The most general status variable which can be a string or numeric. An example of an SI is a string variable which contains the name of the currently logged in user.

119.4 Using Monitor Admin Service

The Monitor Admin service is a singleton service that provides unified access to the Status Variables in the system. It provides security checking, resolution of the Status Variable paths and scheduling of periodic or event based Monitoring Jobs.

119.4.1 Discovery

The Monitor Admin manages the status variables from any registered Monitorable services. The Monitorable services can be discovered using the getMonitorableNames() method. This returns a sorted list of PIDs, or null when no services are registered. This list can contain the PIDs of Monitorable services where the caller has no access to any of its Status Variables.

119.4.2 Status Variable Administration

The Monitor Admin provides the following methods for manipulating the Status Variables:

getStatusVariable(String) – Return a Status Variable given a Status Variable path. A path must have the following syntax:

```
status-variable-path ::= pid '/' status-variable-name
```

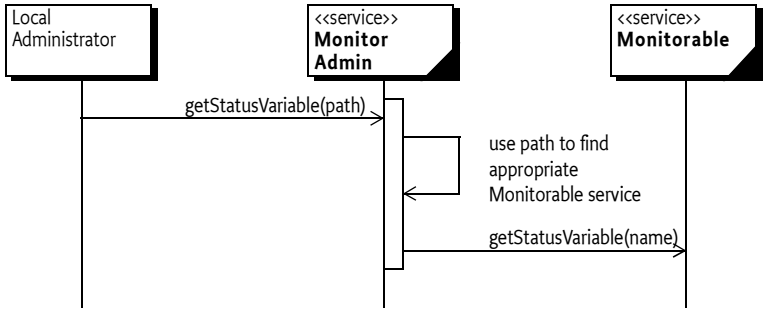
- getStatusVariableNames(String) – Returns the Status Variable names given the PID of a Monitorable service.
- getStatusVariables(String) – Returns an array of Status Variable objects given the PID of a Monitorable service.
- resetStatusVariable(String) – Reset the value of a Status Variable.

Figure 119.4 is the simple sequence diagram for getting a Status Variable from the Monitor Admin service. The caller requests a Status Variable from the Monitor Admin service with the getStatusVariable(String) method. Its sole argument specifies a path to the Status Variable. For example:

```
com.acme.foo/memory.free
```

The Monitor Admin service finds the associated Monitorable service by looking for a Monitorable service with the given PID (com.acme.foo). It will then query the Monitorable service for the Status Variable memory.free, which is then subsequently returned to the caller.

Figure 119.4 Status Variable request through the Monitor Admin service



119.4.3 Notifications

The Monitor Admin service can receive events from Monitorable services as described in *Providing Notifications* on page 435. The Monitor Admin Service can control the sending of events with the switchEvents(String,boolean) method. The argument is a path to a Status Variable, with a possible wildcard character in place of the Status Variable or Monitorable PID. For example:

```
*/*
com.acme.sv.carots/*
*/received.packets
```

The use of wildcards is the same as described in *Monitor Permission* on page 443 The Monitor Admin service must expand this wildcard to the set of Status Variable names at the time the events are switched. If the boolean argument is set to false, no more events will be sent to the Event Admin service.

The default state is sending events. The state of sending events must not be persistent, switching the events off must not be remembered between system restarts.

119.4.4 Monitoring jobs

A local administrator can create a *monitoring job*. A monitoring job consists of a set of Status Variables and *reporting rules*. According to these rules, the Monitor Admin service will send events to the Event Admin service. The same Status Variable can participate in any number of monitoring jobs.

There are two types of monitoring jobs, each created with a different method. One is based on periodic measurements and one based on changes in the value of the Status Variable. The results of the measurements are sent to the Event Admin service, these events are described in *Monitoring events* on page 442.

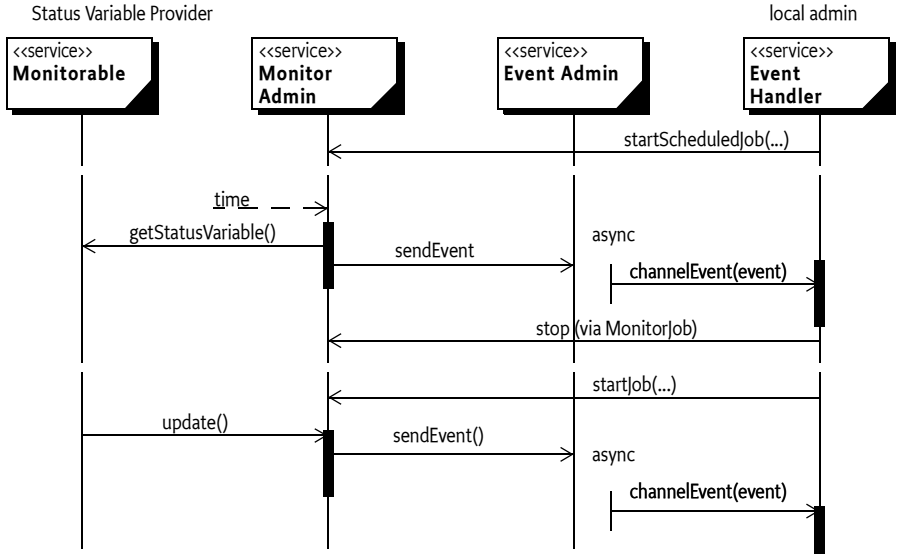
- startScheduledJob(String,String[],int,int) – Start a job based on a periodic measurement. Both the period of measurements as well as the number of measurements can be given.
- startJob(String,String[],int) – Start a job based on notifications. The load on the Event Admin service can be minimized by specifying that only every n-th measurement must be reported. Status Variables used with this monitoring job must support notifications, otherwise an Illegal Argument Exception must be thrown.

Both monitoring jobs take an identification String object as first argument. This identification is placed in the properties of the Event object under the key: listener.id. The initiator of the monitoring job should set this id to a unique value and so that it can discriminate the monitoring events that are related to his monitoring job.

The second argument is a list of paths to Status Variables.

The difference between the Time based monitoring and event based monitoring is further elucidated in Figure 119.5.

Figure 119.5 Time and event based monitoring job



Monitoring jobs can be started also remotely by a management server through Device Management Tree operations. The monitoring job therefore has a boolean method which tells whether it was started locally or remotely: isLocal().

A monitoring job is transient, it must not survive a system restart. A monitoring job can be explicitly stopped with the stop() method.

119.4.4.1 Example Monitoring Job

For example, a bundle is interested in working with periodic samples of the com.acme.foo/memory.free Status Variable. It should therefore register an Event Handler with the correct topic and a filter on its Event Handler service. It then starts a monitoring job that is stopped in the BundleActivator stop method.

```
public class MemoryListener
   implements BundleActivator, EventHandler {
   MonitoringJob job;

   public void start(BundleContext context) throws Exception
{
      Hashtable p = new Hashtable();
      p.put(EventConstants.EVENT_TOPIC,
         new String[] { "org/osgi/service/monitor" });
      p.put(EventConstants.EVENT_FILTER,
         "(mon.listener.id=foo.bar)");

      context.registerService(
         EventHandler.class.getName(),this,p );

      job = getMonitorAdmin().startScheduledJob(
            "foo.bar",    // listener.id
             new String[] {"com.acme.foo/memory.free"},
            15,           // seconds
            0             // Forever
         );
   }

   public void stop(BundleContext ctxt) throws Exception {
      job.stop();
   }

   public void handleEvent(Event event) {
      String value = (String) event.getProperty(
         "mon.statusvariable.value");
      String name = (String) event.getProperty(
         "mon.statusvariable.name");
      System.out.println("Mon: " name + "=" value );
   }
   ...
}
```

After starting the job, the Monitor Admin queries the `com.acme.foo/memory.free` Status Variable every 15 seconds. At each acquisition, the Monitor Admin sends a `org/osgi/service/monitor` event to the Event Admin service. The event properties contain the `mon.listener.id` set to `foo.bar`. The Event Admin service updates the Event Handler service that is registered by the example bundle. After receiving the event, the bundle can get the updated value of the Status Variable from the event properties.

The events are therefore repeated once every 15 seconds until the bundle stops.

119.5 Monitoring events

The Monitor Admin must send an asynchronous event to the Event Admin service when:

- A Monitorable reported the change on the Monitor Listener service
- The Status Variable was explicitly reset to its starting value with the resetStatusVariable(String) method.
- The Status Variable is queried from within a scheduled monitoring job by the Monitor Admin service.

Event sending in the first two cases can be switched on and off, but in the case of monitoring jobs, it cannot be disabled. Monitoring events must be sent asynchronously.

The topic of the event must be:

```
org/osgi/service/monitor
```

The properties of the event are:

- mon.monitorable.pid – (String) The unique identifier of the Monitorable service which the changed Status Variable.
- mon.statusvariable.name – (String) The name of the changed status variable.
- mon.listener.id – (String|String[ ]) Name or names representing the initiators of any monitoring jobs in which the Status Variable was included. Listeners can use this field for filtering, so that they receive only events related to their own jobs. If the event is fired because of a notification on the MonitorListener interface of the Monitor Admin service (and not because of an measurement taken within a monitoring job) then this property is absent.
- mon.statusvariable.value – (String) The value of the status variable in string format. The following methods must be used to format the String object.
  - long – Long.toString(long).
  - double – Double.toString(double).
  - boolean – Boolean.toString(boolean).
  - String – No conversion

119.6 Security

119.6.1 Monitor Permission

Registering Monitorable services, querying and resetting Status Variables and starting monitoring jobs requires a Monitor Permission. If the entity issuing the operation does not have this permission, a Security Exception must be thrown.

Unless noted otherwise, the target of the Monitor Permission identifies the Status Variable paths. It has the following format:

```
widldcard-path ::= wildcard-pid '/' wildcard-name
wildcard-pid  ::= pid '*' ? | '*'
wildcard-name  ::= unique-id '*' ? | '*'
```

Example:

```
*/*
com.acme.*/*
*/count
com.acme.foo/memory.free
```

The actions that can be used are:

- READ –Reading of the value of the given Status Variables.
- RESET – Resetting the given Status Variables.
- PUBLISH – Publishing a Status Variable. This does not forbid the Status Variable Provider to register the Monitorable. However, the Monitor Admin must not show a Status Variables to any caller when the Status Variable Provider has no permission to publish that specific Status Variable.
- STARTJOB – Initiating monitoring jobs involving the given Status Variables A minimal sampling interval can be optionally defined in the following form:

  ```
  startjob:n
  ```

  The n is the allowed minimal value of the schedule parameter of time based monitoring jobs. If n is not specified or zero then there is no lower limit for the minimum sampling interval specified. The purpose of the minimum sampling interval is to prevent the system from flooding. The target specifies the Status Variables that can be monitored.
- SWITCHEVENTS – Switch event sending on or off for the notification of value changes for the given Status Variables.

The permissions must all be checked by the Monitor Admin.

Further, the different actors must have the permissions as specified in Table 119.1 to operate correctly.

119.7 org.osgi.service.monitor

Monitor Admin Package Version 1.0.

Table 119.1 Permission for the different actors

ServicePermission	Status Variable Provider	Local Admin	Monitor Admin
MonitorAdmin	-	GET	REGISTER
UpdateListener	GET	-	REGISTER
Monitorable	REGISTER	-	GET

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.monitor; version=1.0
```

119.7.1 Summary

- Monitorable - A Monitorable can provide information about itself in the form of StatusVariables. [p.444]
- MonitorAdmin - The MonitorAdmin service is a singleton service that handles StatusVariable query requests and measurement job control requests. [p.446]
- MonitoringJob - A Monitoring Job is a request for scheduled or event based notifications on update of a set of StatusVariables. [p.451]
- MonitorListener - The MonitorListener is used by Monitorable services to send notifications when a StatusVariable value is changed. [p.452]
- MonitorPermission - Indicates the callers authority to publish, read or reset StatusVariables, to switch event sending on or off or to start monitoring jobs. [p.452]
- StatusVariable - A StatusVariable object represents the value of a status variable taken with a certain collection method at a certain point of time. [p.455]

119.7.2 public interface Monitorable

A Monitorable can provide information about itself in the form of StatusVariables. Instances of this interface should register themselves at the OSGi Service Registry. The MonitorAdmin listens to the registration of Monitorable services, and makes the information they provide available also through the Device Management Tree (DMT) for remote access.

The monitorable service is identified by its PID string which must be a non-null, non-empty string that conforms to the "symbolic-name" definition in the OSGi core specification. This means that only the characters [-_.a-zA-Z0-9] may be used. The length of the PID must not exceed 20 characters.

A Monitorable may optionally support sending notifications when the status of its StatusVariables change. Support for change notifications can be defined per StatusVariable.

Publishing StatusVariables requires the presence of the MonitorPermission with the publish action string. This permission, however, is not checked during registration of the Monitorable service. Instead, the MonitorAdmin implemenatation must make sure that when a StatusVariable is queried, it is shown only if the Monitorable is authorized to publish the given StatusVariable.

119.7.2.1 public String getDescription(String id) throws

IllegalArgumentException

id the identifier of the StatusVariable, cannot be null

- Returns a human readable description of a StatusVariable. This can be used by management systems on their GUI. The null return value is allowed if there is no description for the specified Status Variable.

  The given identifier does not contain the Monitorable PID, i.e. it specifies the name and not the path of the Status Variable.

Returns the human readable description of this StatusVariable or null if it is not set

Throws `IllegalArgumentException` – if id points to a non-existing StatusVariable

119.7.2.2 public StatusVariable getStatusVariable(String id) throws IllegalArgumentException

id the identifier of the StatusVariable, cannot be null

- Returns the StatusVariable object addressed by its identifier. The StatusVariable will hold the value taken at the time of this method call.

  The given identifier does not contain the Monitorable PID, i.e. it specifies the name and not the path of the Status Variable.

Returns the StatusVariable object

Throws `IllegalArgumentException` – if id points to a non-existing StatusVariable

119.7.2.3 public String[] getStatusVariableNames( )

- Returns the list of StatusVariable identifiers published by this Monitorable. A StatusVariable name is unique within the scope of a Monitorable. The array contains the elements in no particular order. The returned value must not be null.

Returns the StatusVariable identifiers published by this object, or an empty array if none are published

119.7.2.4 public boolean notifiesOnChange(String id) throws IllegalArgumentException

id the identifier of the StatusVariable, cannot be null

- Tells whether the StatusVariable provider is able to send instant notifications when the given StatusVariable changes. If the Monitorable supports sending change updates it must notify the MonitorListener when the value of the StatusVariable changes. The Monitorable finds the MonitorListener service through the Service Registry.

  The given identifier does not contain the Monitorable PID, i.e. it specifies the name and not the path of the Status Variable.

Returns true if the Monitorable can send notification when the given StatusVariable changes, false otherwise

Throws `IllegalArgumentException` – if id points to a non-existing StatusVariable

119.7.2.5 public boolean resetStatusVariable(String id) throws IllegalArgumentException

id the identifier of the StatusVariable, cannot be null

- Issues a request to reset a given StatusVariable. Depending on the semantics of the actual Status Variable this call may or may not succeed: it makes sense to reset a counter to its starting value, but for example a StatusVariable of type String might not have a meaningful default value. Note that for numeric StatusVariables the starting value may not necessarily be 0. Resetting a StatusVariable must trigger a monitor event.

  The given identifier does not contain the Monitorable PID, i.e. it specifies the name and not the path of the Status Variable.

Returns true if the Monitorable could successfully reset the given StatusVariable, false otherwise

Throws `IllegalArgumentException` – if id points to a non-existing StatusVariable

119.7.3 public interface MonitorAdmin

The MonitorAdmin service is a singleton service that handles StatusVariable query requests and measurement job control requests.

Note that an alternative but not recommended way of obtaining StatusVariables is that applications having the required ServicePermissions can query the list of Monitorable services from the service registry and then query the list of StatusVariable names from the Monitorable services. This way all services which publish StatusVariables will be returned regardless of whether they do or do not hold the necessary MonitorPermission for publishing StatusVariables. By using the MonitorAdmin to obtain the StatusVariables it is guaranteed that only those Monitorable services will be accessed who are authorized to publish StatusVariables. It is the responsibility of the MonitorAdmin implementation to check the required permissions and show only those variables which pass this check.

The events posted by MonitorAdmin contain the following properties:

- mon.monitorable.pid: The identifier of the Monitorable
- mon.statusvariable.name: The identifier of the StatusVariable within the given Monitorable
- mon.statusvariable.value: The value of the StatusVariable, represented as a String
- mon.listener.id: The identifier of the initiator of the monitoring job (only present if the event was generated due to a monitoring job)

Most of the methods require either a Monitorable ID or a Status Variable path parameter, the latter in [Monitorable_ID]/[StatusVariable_ID] format. These parameters must not be null, and the IDs they contain must conform to their respective definitions in `Monitorable`[p.444] and `StatusVariable`[p.455] . If any of the restrictions are violated, the method must throw an IllegalArgumentException.

119.7.3.1 public String getDescription(String path) throws IllegalArgumentException, SecurityException

path the full path of the StatusVariable in [Monitorable_ID]/[StatusVariable_ID] format

- Returns a human readable description of the given StatusVariable. The null value may be returned if there is no description for the given StatusVariable.

The entity that queries a StatusVariable needs to hold MonitorPermission for the given target with the read action present.

Returns the human readable description of this StatusVariable or null if it is not set

Throws `IllegalArgumentException` – if path is null or otherwise invalid, or points to a non-existing StatusVariable

`SecurityException` – if the caller does not hold a MonitorPermission for the StatusVariable specified by path with the read action present

119.7.3.2 public String[] getMonitorableNames( )

- Returns the names of the Monitorable services that are currently registered. The Monitorable instances are not accessible through the MonitorAdmin, so that requests to individual status variables can be filtered with respect to the publishing rights of the Monitorable and the reading rights of the caller.

  The returned array contains the names in alphabetical order. It cannot be null, an empty array is returned if no Monitorable services are registered.

Returns the array of Monitorable names

119.7.3.3 public MonitoringJob[] getRunningJobs( )

- Returns the list of currently running MonitoringJobs. Jobs are only visible to callers that have the necessary permissions: to receive a Monitoring Job in the returned list, the caller must hold all permissions required for starting the job. This means that if the caller does not have MonitorPermission with the proper startjob action for all the Status Variables monitored by a job, then that job will be silently omitted from the results.

  The returned array cannot be null, an empty array is returned if there are no running jobs visible to the caller at the time of the call.

Returns the list of running jobs visible to the caller

119.7.3.4 public StatusVariable getStatusVariable(String path) throws IllegalArgumentException, SecurityException

path the full path of the StatusVariable in [Monitorable_ID]/[StatusVariable_ID] format

- Returns a StatusVariable addressed by its full path. The entity which queries a StatusVariable needs to hold MonitorPermission for the given target with the read action present.

Returns the StatusVariable object

Throws `IllegalArgumentException` – if path is null or otherwise invalid, or points to a non-existing StatusVariable

`SecurityException` – if the caller does not hold a MonitorPermission for the StatusVariable specified by path with the read action present

119.7.3.5 public String[] getStatusVariableNames(String monitorableId) throws IllegalArgumentException

monitorableId the identifier of a Monitorable instance

- Returns the list of StatusVariable names published by a Monitorable instance. Only those status variables are listed where the following two conditions are met:

- the specified Monitorable holds a MonitorPermission for the status variable with the publish action present
- the caller holds a MonitorPermission for the status variable with the read action present

The returned array does not contain duplicates, and the elements are in alphabetical order. It cannot be null, an empty array is returned if no (authorized and readable) Status Variables are provided by the given Monitorable.

Returns a list of StatusVariable objects names published by the specified Monitorable

Throws `IllegalArgumentException` – if monitorableId is null or otherwise invalid, or points to a non-existing Monitorable

119.7.3.6 public StatusVariable[] getStatusVariables(String monitorableId) throws IllegalArgumentException

monitorableId the identifier of a Monitorable instance

□ Returns the StatusVariable objects published by a Monitorable instance. The StatusVariables will hold the values taken at the time of this method call. Only those status variables are returned where the following two conditions are met:

- the specified Monitorable holds a MonitorPermission for the status variable with the publish action present
- the caller holds a MonitorPermission for the status variable with the read action present

The elements in the returned array are in no particular order. The return value cannot be null, an empty array is returned if no (authorized and readable) Status Variables are provided by the given Monitorable.

Returns a list of StatusVariable objects published by the specified Monitorable

Throws `IllegalArgumentException` – if monitorableId is null or otherwise invalid, or points to a non-existing Monitorable

119.7.3.7 public boolean resetStatusVariable(String path) throws IllegalArgumentException, SecurityException

path the identifier of the StatusVariable in [Monitorable_id]/[StatusVariable_id] format

□ Issues a request to reset a given StatusVariable. Depending on the semantics of the StatusVariable this call may or may not succeed: it makes sense to reset a counter to its starting value, but e.g. a StatusVariable of type String might not have a meaningful default value. Note that for numeric StatusVariables the starting value may not necessarily be 0. Resetting a StatusVariable triggers a monitor event if the StatusVariable supports update notifications.

The entity that wants to reset the StatusVariable needs to hold MonitorPermission with the reset action present. The target field of the permission must match the StatusVariable name to be reset.

Returns true if the Monitorable could successfully reset the given StatusVariable, false otherwise

Throws `IllegalArgumentException` – if path is null or otherwise invalid, or points to a non-existing StatusVariable

`SecurityException` – if the caller does not hold MonitorPermission with the reset action or if the specified StatusVariable is not allowed to be reset as per the target field of the permission

119.7.3.8 public MonitoringJob startJob(String initiator, String[] statusVariables, int count) throws IllegalArgumentException, SecurityException

initiator the identifier of the entity that initiated the job

statusVariables the list of StatusVariables to be monitored, with each StatusVariable name given in [Monitorable_PID]/[StatusVariable_ID] format

count the number of changes that must happen to a StatusVariable before a new notification is sent

- Starts a change based MonitoringJob with the parameters provided. Monitoring events will be sent when the StatusVariables of this job are updated. All specified StatusVariables must exist when the job is started, and all must support update notifications. The initiator string is used in the mon.listener.id field of all events triggered by the job, to allow filtering the events based on the initiator.

  The count parameter specifies the number of changes that must happen to a StatusVariable before a new notification is sent, this must be a positive integer.

  The entity which initiates a MonitoringJob needs to hold MonitorPermission for all the specified target StatusVariables with the startjob action present.

Returns the successfully started job object, cannot be null

Throws `IllegalArgumentException` – if the list of StatusVariable names contains an invalid or non-existing StatusVariable, or one that does not support notifications; if the initiator is null or empty; or if count is invalid

`SecurityException` – if the caller does not hold MonitorPermission for all the specified StatusVariables, with the startjob action present

119.7.3.9 public MonitoringJob startScheduledJob(String initiator, String[] statusVariables, int schedule, int count) throws IllegalArgumentException, SecurityException

initiator the identifier of the entity that initiated the job

statusVariables the list of StatusVariables to be monitored, with each StatusVariable name given in [Monitorable_PID]/[StatusVariable_ID] format

schedule the time in seconds between two measurements

count the number of measurements to be taken, or 0 for the measurement to run until explicitely stopped

- Starts a time based MonitoringJob with the parameters provided. Monitoring events will be sent according to the specified schedule. All specified StatusVariables must exist when the job is started. The initiator string is used in the mon.listener.id field of all events triggered by the job, to allow filtering the events based on the initiator.

The schedule parameter specifies the time in seconds between two measurements, it must be greater than 0. The first measurement will be taken when the timer expires for the first time, not when this method is called.

The count parameter defines the number of measurements to be taken, and must either be a positive integer, or 0 if the measurement is to run until explicitely stopped.

The entity which initiates a MonitoringJob needs to hold MonitorPermission for all the specified target StatusVariables with the startjob action present. If the permission's action string specifies a minimal sampling interval then the schedule parameter should be at least as great as the value in the action string.

Returns the successfully started job object, cannot be null

Throws `IllegalArgumentException` – if the list of StatusVariable names contains an invalid or non-existing StatusVariable; if initiator is null or empty; or if the schedule or count parameters are invalid

`SecurityException` – if the caller does not hold MonitorPermission for all the specified StatusVariables, with the startjob action present, or if the permission does not allow starting the job with the given frequency

119.7.3.10 public void switchEvents(String path, boolean on) throws IllegalArgumentException, SecurityException

path the identifier of the StatusVariable(s) in [Monitorable_id]/[StatusVariable_id] format, possibly with the "*" wildcard at the end of either path fragment

on false if event sending should be switched off, true if it should be switched on for the given path

□ Switches event sending on or off for the specified StatusVariables. When the MonitorAdmin is notified about a StatusVariable being updated it sends an event unless this feature is switched off. Note that events within a monitoring job can not be switched off. The event sending state of the StatusVariables must not be persistently stored. When a StatusVariable is registered for the first time in a framework session, its event sending state is set to ON by default.

Usage of the "*" wildcard is allowed in the path argument of this method as a convenience feature. The wildcard can be used in either or both path fragments, but only at the end of the fragments. The semantics of the wildcard is that it stands for any matching StatusVariable at the time of the method call, it does not affect the event sending status of StatusVariables which are not yet registered. As an example, when the switchEvents("MyMonitorable/*", false) method is executed, event sending from all StatusVariables of the MyMonitorable service are switched off. However, if the MyMonitorable service starts to publish a new StatusVariable later, it's event sending status is on by default.

Throws `SecurityException` – if the caller does not hold MonitorPermission with the switchevents action or if there is any StatusVariable in the path field for which it is not allowed to switch event sending on or off as per the target field of the permission

`IllegalArgumentException` – if path is null or otherwise invalid, or points to a non-existing StatusVariable

119.7.4 public interface MonitoringJob

A Monitoring Job is a request for scheduled or event based notifications on update of a set of StatusVariables. The job is a data structure that holds a non-empty list of StatusVariable names, an identification of the initiator of the job, and the sampling parameters. There are two kinds of monitoring jobs: time based and change based. Time based jobs take samples of all StatusVariables with a specified frequency. The number of samples to be taken before the job finishes may be specified. Change based jobs are only interested in the changes of the monitored StatusVariables. In this case, the number of changes that must take place between two notifications can be specified.

The job can be started on the MonitorAdmin interface. Running the job (querying the StatusVariables, listening to changes, and sending out notifications on updates) is the task of the MonitorAdmin implementation.

Whether a monitoring job keeps track dynamically of the StatusVariables it monitors is not specified. This means that if we monitor a StatusVariable of a Monitorable service which disappears and later reappears then it is implementation specific whether we still receive updates of the StatusVariable changes or not.

119.7.4.1 public String getInitiator( )

- Returns the identitifier of the principal who initiated the job. This is set at the time when MonitorAdmin.startJob MonitorAdmin.startJob()[p.449] method is called. This string holds the ServerID if the operation was initiated from a remote manager, or an arbitrary ID of the initiator entity in the local case (used for addressing notification events).

Returns the ID of the initiator, cannot be null

119.7.4.2 public int getReportCount( )

- Returns the number of times MonitorAdmin will query the StatusVariables (for time based jobs), or the number of changes of a StatusVariable between notifications (for change based jobs). Time based jobs with non-zero report count will take getReportCount()*getSchedule() time to finish. Time based jobs with 0 report count and change based jobs do not stop automatically, but all jobs can be stopped with the `stop`[p.452] method.

Returns the number of measurements to be taken, or the number of changes between notifications

119.7.4.3 public int getSchedule( )

- Returns the delay (in seconds) between two samples. If this call returns N (greater than 0) then the MonitorAdmin queries each StatusVariable that belongs to this job every N seconds. The value 0 means that the job is not scheduled but event based: in this case instant notification on changes is requested (at every nth change of the value, as specified by the report count parameter).

Returns the delay (in seconds) between samples, or 0 for change based jobs

119.7.4.4 public String[] getStatusVariableNames( )

- Returns the list of StatusVariable names that are the targets of this measurement job. For time based jobs, the MonitorAdmin will iterate through this list and query all StatusVariables when its timer set by the job's frequency rate expires.

Returns the target list of the measurement job in [Monitorable_ID]/[StatusVariable_ID] format, cannot be null

119.7.4.5 public boolean isLocal( )

- Returns whether the job was started locally or remotely. Jobs started by the clients of this API are always local, remote jobs can only be started using the Device Management Tree.

Returns true if the job was started from the local device, false if the job was initiated from a management server through the device management tree

119.7.4.6 public boolean isRunning( )

- Returns whether the job is running. A job is running until it is explicitely stopped, or, in case of time based jobs with a finite report count, until the given number of measurements have been made.

Returns true if the job is still running, false if it has finished

119.7.4.7 public void stop( )

- Stops a Monitoring Job. Note that a time based job can also stop automatically if the specified number of samples have been taken.

119.7.5 public interface MonitorListener

The MonitorListener is used by Monitorable services to send notifications when a StatusVariable value is changed. The MonitorListener should register itself as a service at the OSGi Service Registry. This interface must (only) be implemented by the Monitor Admin component.

119.7.5.1 public void updated(String monitorableId, StatusVariable statusVariable) throws IllegalArgumentException

monitorableId the identifier of the Monitorable instance reporting the change

statusVariable the StatusVariable that has changed

- Callback for notification of a StatusVariable change.

Throws `IllegalArgumentException` – if the specified monitorable ID is invalid (null, empty, or contains illegal characters) or points to a non-existing Monitorable, or if statusVariable is null

119.7.6 public class MonitorPermission extends Permission

Indicates the callers authority to publish, read or reset StatusVariables, to switch event sending on or off or to start monitoring jobs. The target of the permission is the identifier of the StatusVariable, the action can be read, publish, reset, startjob, switchevents, or the combination of these separated by commas. Action names are interpreted case-insensitively, but the canonical action string returned by getActions[p.454] uses the forms defined by the action constants.

If the wildcard * appears in the actions field, all legal monitoring commands are allowed on the designated target(s) by the owner of the permission.

119.7.6.1 public static final String PUBLISH = "publish"

Holders of MonitorPermission with the publish action present are Monitorable services that are allowed to publish the StatusVariables specified in the permission's target field. Note, that this permission cannot be enforced when a Monitorable registers to the framework, because the Service Registry does not know about this permission. Instead, any StatusVariables published by a Monitorable without the corresponding publish permission are silently ignored by MonitorAdmin, and are therefore invisible to the users of the monitoring service.

119.7.6.2 public static final String READ = "read"

Holders of MonitorPermission with the read action present are allowed to read the value of the StatusVariables specified in the permission's target field.

119.7.6.3 public static final String RESET = "reset"

Holders of MonitorPermission with the reset action present are allowed to reset the value of the StatusVariables specified in the permission's target field.

119.7.6.4 public static final String STARTJOB = "startjob"

Holders of MonitorPermission with the startjob action present are allowed to initiate monitoring jobs involving the StatusVariables specified in the permission's target field.

A minimal sampling interval can be optionally defined in the following form: startjob:n. This allows the holder of the permission to initiate time based jobs with a measurement interval of at least n seconds. If n is not specified or 0 then the holder of this permission is allowed to start monitoring jobs specifying any frequency.

119.7.6.5 public static final String SWITCHEVENTS = "switchevents"

Holders of MonitorPermission with the switchevents action present are allowed to switch event sending on or off for the value of the StatusVariables specified in the permission's target field.

119.7.6.6 public MonitorPermission(String statusVariable, String actions) throws

IllegalArgumentException

statusVariable the identifier of the StatusVariable in [Monitorable_id]/[StatusVariable_id] format

actions the list of allowed actions separated by commas, or * for all actions

- Create a MonitorPermission object, specifying the target and actions.

  The statusVariable parameter is the target of the permission, defining one or more status variable names to which the specified actions apply. Multiple status variable names can be selected by using the wildcard * in the target string. The wildcard is allowed in both fragments, but only at the end of the fragments.

  For example, the following targets are valid: com.mycomp.myapp/queue_length, com.mycomp.myapp/*, com.mycomp.*/*, */*, */queue_length, */queue*.

  The following targets are invalid: *.myapp/queue_length, com.*.myapp/*, *.

  The actions parameter specifies the allowed action(s): read, publish, startjob, reset, switchevents, or the combination of these separated by commas. String constants are defined in this class for each valid action. Passing "*" as the action string is equivalent to listing all actions.

Throws `IllegalArgumentException` – if either parameter is null, or invalid with regard to the constraints defined above and in the documentation of the used actions

119.7.6.7 public boolean equals(Object o)

o the object being compared for equality with this object

- Determines the equality of two MonitorPermission objects. Two MonitorPermission objects are equal if their target strings are equal and the same set of actions are listed in their action strings.

Returns true if the two permissions are equal

119.7.6.8 public String getActions( )

- Get the action string associated with this permission. The actions are returned in the following order: read, reset, publish, startjob, switchevents.

Returns the allowed actions separated by commas, cannot be null

119.7.6.9 public int hashCode( )

- Create an integer hash of the object. The hash codes of MonitorPermissions p1 and p2 are the same if p1.equals(p2).

Returns the hash of the object

119.7.6.10 public boolean implies(Permission p)

p the permission to be checked

- Determines if the specified permission is implied by this permission.

  This method returns false if and only if at least one of the following conditions are fulfilled for the specified permission:

  - it is not a MonitorPermission

- it has a broader set of actions allowed than this one
- it allows initiating time based monitoring jobs with a lower minimal sampling interval
- the target set of Monitorables is not the same nor a subset of the target set of Monitorables of this permission
- the target set of StatusVariables is not the same nor a subset of the target set of StatusVariables of this permission

Returns true if the given permission is implied by this permission

119.7.7 public final class StatusVariable

A StatusVariable object represents the value of a status variable taken with a certain collection method at a certain point of time. The type of the StatusVariable can be int, float, boolean or String.

A StatusVariable is identified by an ID string that is unique within the scope of a Monitorable. The ID must be a non- null, non-empty string that conforms to the "symbolic-name" definition in the OSGi core specification. This means that only the characters [-_.a-zA-Z0-9] may be used. The length of the ID must not exceed 32 bytes when UTF-8 encoded.

119.7.7.1 public static final int CM_CC = 0

Constant for identifying 'Cumulative Counter' data collection method.

119.7.7.2 public static final int CM_DER = 1

Constant for identifying 'Discrete Event Registration' data collection method.

119.7.7.3 public static final int CM_GAUGE = 2

Constant for identifying 'Gauge' data collection method.

119.7.7.4 public static final int CM_SI = 3

Constant for identifying 'Status Inspection' data collection method.

119.7.7.5 public static final int TYPE_BOOLEAN = 3

Constant for identifying boolean data type.

119.7.7.6 public static final int TYPE_FLOAT = 1

Constant for identifying float data type.

119.7.7.7 public static final int TYPE_INTEGER = 0

Constant for identifying int data type.

119.7.7.8 public static final int TYPE_STRING = 2

Constant for identifying String data type.

119.7.7.9 public StatusVariable(String id, int cm, int data)

id the identifier of the StatusVariable

cm the collection method, one of the CM_ constants

data the int value of the StatusVariable

- Constructor for a StatusVariable of int type.

Throws `IllegalArgumentException` – if the given id is not a valid StatusVariable name, or if cm is not one of the collection method constants

`NullPointerException` – if the id parameter is null

119.7.7.10 public StatusVariable(String id, int cm, float data)

id the identifier of the StatusVariable

cm the collection method, one of the CM_ constants

data the float value of the StatusVariable

- Constructor for a StatusVariable of float type.

Throws `IllegalArgumentException` – if the given id is not a valid StatusVariable name, or if cm is not one of the collection method constants

`NullPointerException` – if the id parameter is null

119.7.7.11 public StatusVariable(String id, int cm, boolean data)

id the identifier of the StatusVariable

cm the collection method, one of the CM_ constants

data the boolean value of the StatusVariable

- Constructor for a StatusVariable of boolean type.

Throws `IllegalArgumentException` – if the given id is not a valid StatusVariable name, or if cm is not one of the collection method constants

`NullPointerException` – if the id parameter is null

119.7.7.12 public StatusVariable(String id, int cm, String data)

id the identifier of the StatusVariable

cm the collection method, one of the CM_ constants

data the String value of the StatusVariable, can be null

- Constructor for a StatusVariable of String type.

Throws `IllegalArgumentException` – if the given id is not a valid StatusVariable name, or if cm is not one of the collection method constants

`NullPointerException` – if the id parameter is null

119.7.7.13 public boolean equals(Object obj)

obj the object to compare with this StatusVariable

- Compares the specified object with this StatusVariable. Two StatusVariable objects are considered equal if their full path, collection method and type are identical, and the data (selected by their type) is equal.

Returns true if the argument represents the same StatusVariable as this object

119.7.7.14 public boolean getBoolean( ) throws IllegalStateException

- Returns the StatusVariable value if its type is boolean.

Returns the StatusVariable value as a boolean

Throws `IllegalStateException` – if the type of this StatusVariable is not boolean

119.7.7.15 public int getCollectionMethod( )

- Returns the collection method of this StatusVariable. See section 3.3 b) in [ETSI TS 132 403]

Returns one of the CM_ constants

119.7.7.16 public float getFloat( ) throws IllegalStateException

- Returns the StatusVariable value if its type is float.

Returns the StatusVariable value as a float

Throws `IllegalStateException` – if the type of this StatusVariable is not float

119.7.7.17 public String getID( )

- Returns the ID of this StatusVariable. The ID is unique within the scope of a Monitorable.

Returns the ID of this StatusVariable

119.7.7.18 public int getInteger( ) throws IllegalStateException

- Returns the StatusVariable value if its type is int.

Returns the StatusVariable value as an int

Throws `IllegalStateException` – if the type of this StatusVariable is not int

119.7.7.19 public String getString( ) throws IllegalStateException

- Returns the StatusVariable value if its type is String.

Returns the StatusVariable value as a String

Throws `IllegalStateException` – if the type of the StatusVariable is not String

119.7.7.20 public Date getTimeStamp( )

- Returns the timestamp associated with the StatusVariable. The timestamp is stored when the StatusVariable instance is created, generally during the Monitorable.getStatusVariable[p.445] method call.

Returns the time when the StatusVariable value was queried, cannot be null

119.7.7.21 public int getType( )

- Returns information on the data type of this StatusVariable.

Returns one of the TYPE_ constants indicating the type of this StatusVariable

119.7.7.22 public int hashCode( )

- Returns the hash code value for this StatusVariable. The hash code is calculated based on the full path, collection method and value of the StatusVariable.

Returns the hash code of this object

119.7.7.23 public String toString( )

- Returns a String representation of this StatusVariable. The returned String contains the full path, collection method, timestamp, type and value parameters of the StatusVariable in the following format:

`StatusVariable(<path>, <cm>, <timestamp>, <type>, <value>)`

The collection method identifiers used in the string representation are “CC”, “DER”, “GAUGE” and “SI” (without the quotes). The format of the timestamp is defined by the Date.toString method, while the type is identified by one of the strings “INTEGER”, “FLOAT”, “STRING” and “BOOLEAN”. The final field contains the string representation of the value of the status variable.

Returns the String representation of this StatusVariable

119.8 References

[1] *SyncML Device Management Tree Description*

[2] *ETSI Performance Management [TS 132 403]*
http://webapp.etsi.org/action/PU/20040113/ts_132403v050500p.pdf

[3] *RFC-2396 Uniform Resource Identifiers (URI): Generic Syntax*
http://www.ietf.org/rfc/rfc2396.txt

120 Foreign Application Access Specification

Version 1.0

120.1 Introduction

The OSGi Framework contains an advanced collaboration model which provides a publish/find/bind model using *services*. This OSGi service architecture is not natively supported by foreign application models like MIDP, Xlets, Applets, other Java application models. The purpose of this specification is to enable these foreign applications to participate in the OSGi service oriented architecture.

120.1.1 Essentials

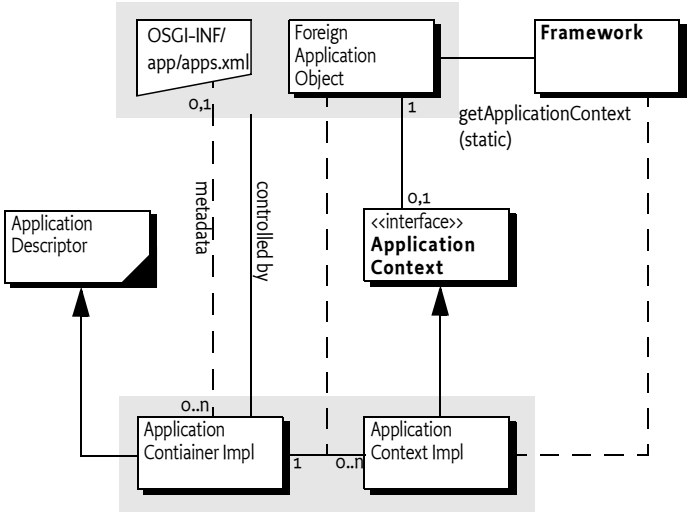
- *Interoperatbility* – Full inter-operability between foreign application models and OSGi services is required. This requires both getting services, registering services, and listening to Framework events.
- *No Change* – The interworking specification cannot modify the life cycle model of the foreign application models. The foreign application model specifications cannot be changed.
- *Familiarity* – Programmers familiar with a foreign application model should be able to leverage the services architecture without much effort.
- *Simplicity* – The programming model for using services must be very simple and not require the programmer to learn many new concepts.
- *Management* – Support managing the foreign applications; both through proper OSGi APIs and from a remote management server.

120.1.2 Entities

- *Foreign Application* – Java Applications, which must be delivered in JAR files, which are not OSGi bundles.
- *Application Container* – An Application Container is responsible for controlling a foreign application and providing the appropriate environment. It must interact with the OSGi Framework to give the foreign application instances access to the OSGi services and package sharing.
- *Application Activator* – A class in the foreign application JAR file that is used to notify the application of life cycle changes. One JAR file can contain multiple application activators.
- *Framework* – A class that provides access to the application container's *application context* for a given application activator.
- *Application Context* – The interface to the application container's functions to inter-work with the OSGi Framework.
- *Application Declaration* – An XML resource that must be placed in the application's JAR file at `OSGI-INF/app/apps.xml`. This is an optional declaration.

- *Application Instance* – A launched application. Most foreign application models permit an application to be launched multiple times.

Figure 120.1 Foreign Applications, org.osgi.application package



120.1.3 Synopsis

Foreign application JAR files can be installed in an OSGi Framework as if they were normal bundles. Application containers running on the OSGi Framework must detect the installation of recognized foreign applications and provide a bridge to the OSGi Environment. This bridge can include interaction with the *Application Admin Service Specification* on page 269, as well as provide access to the OSGi services and Framework events.

The Application container reads the application XML resource from the JAR file and treats the foreign application according to this information. When the foreign application is launched, the application container creates an application instance.

Foreign application instances can get an application context through a static method on the Framework class. The Application Context provides access to getting services, registering services and registering listeners.

The foreign application instance's life cycle can be influenced by the application declaration. If desired, an application can be prevented from launching or stopping when required services are, or become, unavailable.

120.2 Foreign Applications

Foreign applications are Java applications that can be installed and managed through the normal OSGi mechanisms. However, they use another application programming model than the bundle programming model. For example: MIDP, MHP, DOJA.

Foreign applications must fulfill the following requirements to be able to inter-work with the OSGi environment:

- The applications must be written in Java
- The applications must be delivered in JAR files. This is the common model for Java applications.
- They must have a clearly defined life cycle with a start and stop state.
- One or more classes in the application must be available to start and stop the application. For example the Midlet in MIDP or the Xlet in MHP. This object is called the *application's activator*. As the application container uses this object for life cycle control of the application, the lifetime of this object equals the lifetime of the application.

Foreign applications are managed by *application containers*. Application containers provide the environment and life cycle management as defined by foreign application model.

This specification does not require any changes in the foreign application model; existing applications must run unmodified. However, to allow the foreign applications to participate as a first class OSGi citizen, a number of additional artifacts in the JAR file are required. These artifacts use Manifest headers and an XML resource in the applications JAR file; these artifacts are permitted and ignored by the foreign application models that are currently known.

120.2.1 Foreign Metadata

There are different types of metadata associated with application models. Descriptive information, for example the name, icon, documentation etc. of the application, is usually provided in an application model specific way. Application models can also define behavioral metadata, that is, prescribe that the application needs to be started automatically at device startup (auto start) or whether multiple instances of an application can be executed concurrently (singleton). These kinds of metadata are supported by different application models to different extent and are not in the scope of this specification. The application container is responsible for interpreting this metadata and treating the foreign application in the appropriate way.

120.2.2 OSGi Manifest Headers

Foreign applications can import packages by specifying the appropriate OSGi module headers in the manifest. These headers are fully described in the OSGi Core Specification. Their semantics remain unchanged. The following headers must not be used in foreign applications:

- *Export-Package* – Exporting packages is forbidden in foreign applications.
- *Bundle-Activator* – Foreign applications have their own activator.
- *Service-Component* – Service components should be bundles.

Foreign applications that intend to use the OSGi Framework features should have Bundle-SymbolicName and Bundle-Version headers. If they do not have such a header, they can be deployed with Deployment Package, which can assign these headers in the Deployment Package manifest.

Any JAR that uses these headers must not be recognized as a foreign application, even if their manifest is conforming and valid with respect to the foreign application model. This entails that a JAR cannot both be a bundle with activator or exports and a foreign application.

For example, a MIDlet can be extended to import the org.osgi.application package from the OSGi environment. The Import-Package header is used to describe such an import:

```
Manifest-Version: 1.0
MIDlet-Name: Example
MIDlet-1: Example, , osgi.ExampleMidlet
MIDlet-Version: 1.1.0
MIDlet-Vendor: OSGi
MicroEdition-Configuration: CDC-1.0
MicroEdition-Profile: MIDP-1.0
Bundle-ManifestVersion: 2
Bundle-SymbolicName: osgi.example
Import-Package: org.osgi.application;version=1.0,
  org.osgi.framework;version=1.3
```

120.2.3 Interacting with the OSGi Framework

The application container must maintain an application context for each started application, that is, the application instance. This context is related to the application's activator. The Application Context can be acquired using a static getApplicationContext(Object) method on the Framework class. The parameter of this method is the application's activator itself. The getApplicationContext method cannot check if the caller is really the given application; the application activator is therefore a *capability*, any application that has this object can get the Application Context. The application activator should never be shared with other applications. The Application Context must therefore deny the application activator to be used as a service object.

The getApplicationContext method must not be called from the application activator's constructor; at that time it must not be available yet.

For example, a MIDlet could acquire the application context with the following code:

```
import org.osgi.framework.*;
import org.osgi.application.*;
import javax.microedition.midlet.*;

public class Example extends MIDlet {
   ApplicationContext    context;
    public void startApp() {
        context = Framework.getApplicationContext(this);
    }

    public void pauseApp() { ... }

    public void destroyApp(boolean unconditional) { ... }
}
```

The getApplicationContext method must throw an Illegal Argument Exception if it is called with an object that is not an application's activator.

The ApplicationContext object is singleton for the corresponding application's activator. Subsequent calls to the getApplicationContext method with the same application's activator must return the same ApplicationContext object; therefore, applications are free to forget and get the object any number of times during their lifetime. However, it is an error to get the ApplicationContext object for an application that is already stopped. Existing ApplicationContext objects must be invalidated once the application's activator is stopped.

120.2.4 Introspection

The Application Context provides the following methods about the application:

- getApplicationId() – Return the Application Descriptor id for this application.
- getInstanceId() – Return the instance id for this application.

120.2.5 Access to Services

Foreign applications do not have direct access to the OSGi service registry. However, the application context provides the mechanism to interact with this service registry.

Access to services is more protected and controlled than traditional OSGi access that uses the BundleContext object. The service model is conceptually based on the *Declarative Services Specification* on page 151. It uses the same concepts as that specification. Albeit there are a number of differences due the nature of foreign applications.

Applications can use the locateService or locateServices methods of their associated application context to obtain service objects from the OSGi service registry. Just like OSGi Declarative services, these service objects must be declared a priori in the reference element of the metadata, see *Application Descriptor Resource* on page 467. This metadata declares a number of *named references*; References contain the criteria which services are eligible for use by the application and how these dependencies should be handled. The foreign application can only use services defined in references; the application context only takes the name of a reference as parameter in the locateService and locateServices methods. That is, a foreign application cannot indiscriminately use the service registry, it is restricted by the application declaration.

A reference *selects* a subset of services in the service registry. The primary selector is its *interface*. However, this subset can be further narrowed down with a *target* filter. The target specifies an OSGi filter expression that is used to additionally qualify the subset of appropriate services.

There are two different methods to access the services selected by the reference:

- locateService(String) – Return one of the services that is selected by the reference with the given name. If multiple services are selected by the reference, then the service with the highest ranking must be returned.

This is compatible with the getServiceReference method in the OSGi Framework's BundleContext class.
- locateServices(String) – Return all the services that are selected by the reference with the given name.

Once the application instance has obtained a service object, that service is said to be *bound* to the application instance. There is no method to unbind a service.

For example, a foreign application that wants to log via the Log Service, should declare the following metadata in OSGI-INF/app/apps.xml:

```
<?xml version="1.0" ?>
   <descriptor xmlns="http://www.osgi.org/xmlns/app/v1.0.0">
      <application class="com.acme.app.SampleMidlet">
      <reference name="log"
         interface="org.osgi.service.log.LogService"/>
   </application>
</descriptor>
```

The code to log could look like:

```
void log(String msg) {
   ApplicationContext ctxt=
      Framework.getApplicationContext(this);
   LogService log = (LogService) ctxt.locateService("log");
   log.log( LogService.LOG_INFO, msg );
}
```

120.2.6 Service Properties

The foreign applications receive the services objects they have access to directly. This means that they cannot access the service properties that are normally associated with the service registrations.

The getServiceProperties(Object) returns a Map object with a copy of these service properties.

120.2.7 Dependencies on Services

The availability of services can influence the life cycle of the foreign application. The life cycle is influenced by the *policy* and the *cardinality*.

The policy defines how the unregistration of a bound service must be handled. The following policies are supported:

- *static* – The application assumes that bound services will never go away. So if a bound service becomes unregistered, the Application Container must stop the application to prevent it from using a stale service.
- *dynamic* – The application must never store service objects and will always get them on demand. Once a service is bound, it can become unregistered without any effect on the application.

Additionally, the *cardinality* defines if a reference is optional. An optional reference does not influence the life cycle of an application, a mandatory reference does. The cardinality is expressed as one of the following values:

- 0..1 or 0..n – Optional reference
- 1..1 or 1..n – Mandatory reference

The multiplicity is only for compatibility with the Declarative Services. Both locateService and locateServices methods can be used regardless of the given multiplicity and return the selected subset for the given reference.

Mandatory references can influence the launching of an application. An application must only be started when a mandatory reference is *satisfied*. A reference is satisfied when there is at least one registered service selected by the reference.

If a mandatory reference of an application is about to become unsatisfied, due to unregistering a service, the application container must stop the application instance according to corresponding application model semantics.

120.2.8 Registering Services

A common pattern in the OSGi is registering a service to listen to certain events. For example, the Configuration Admin service requires their clients to register a callback Managed Service, so that the service can asynchronously update the client with new configurations. The ApplicationContext interface contains methods that allow the applications to register such services. These services must be automatically unregistered by the application container after the application has been stopped.

The available methods are:

- registerService(String[],Object,Dictionary) – Register a service under a single interface.
- registerService(String,Object,Dictionary) – Register a service under a number of interfaces.

Either method requires that the given object implements all the interfaces that are given. The Dictionary object provides the properties. See the OSGi registerService methods in the BundleContext class. These identical methods specifies the behavior in detail.

The use of the application activator as a service object is explicitly forbidden. Registering the application activator as a service allows other applications in the OSGi environment to access the Application Context using this object and the getApplicationContext method.

Both methods return a ServiceRegistration object that can be used to unregister the service. Services must be automatically unregistered when the application instance is stopped.

120.2.9 Listening to Service Events

The Application Context provides the following methods to listen to service events:

- addServiceListener(ApplicationServiceListener,String) – Add an Application Service Listener. The listener will receive the service events for the given reference name.
- addServiceListener(ApplicationServiceListener,String[]) – Add an Application Service Listener that will receive the events for all the services identified with the given reference name.

If a Application Service Listener is registered more than once, then the previous registration is removed. Listeners can be removed with removeServiceListener(ApplicationServiceListener). When the application instance is stopped, the listeners are automatically unregistered.

120.2.10 Access to Startup Parameters

Applications can use the getStartupArguments method on the application context to obtain their startup arguments. The startup arguments are represented as map with name and value pairs. The name is a non-null and non-empty ("") String object. The value can be any type of object.

The reason for providing the startup parameters through a special mechanism is that it allows foreign applications access to the parameters of a schedule application, see *Scheduling* on page 275.

This uniform access to the startup parameters provides a uniform way for applications of any foreign application model. This facility does not remove the need for any mechanisms required by the foreign application model for startup parameters access.

120.2.11 Sibling Instances

Most foreign application models allow an application to be launched multiple times, creating multiple instances. In OSGi, a bundle can only be started once, which creates certain assumptions. For example, the Service Factory concept creates a unique service object per bundle.

Each application instance must be seen as a unique bundle while it runs. That is, it should not share anything with other instances. The foreign application container is responsible for this isolation; implementing this isolation requires implementation dependent constructs.

120.3 Application Containers

Application containers:

- Provide management for the foreign applications
- Launches application instances in a defined environment
- Provide a specific a application model context to foreign application instances
- Interact with the Application Admin service to provide the foreign applications to application managers.

A single OSGi environment can host multiple application containers.

120.3.1 Installation

Applications are installed into the system using OSGi bundle installation mechanism (i.e. installBundle method of the BundleContext interface). This allows including application JARs to Deployment Packages without any changes to the Deployment Package format or Deployment Admin behavior. It also allows the OSGi framework to process the dependency information (the package dependencies) included in the application metadata.

The application container can listen to the BundleEvent.INSTALLED events and examine the installed JARs whether they contain applications supported by the particular container. After the installation, the application container is responsible for registering the corresponding Application Descriptor as defined in the *Application Admin Service Specification* on page 269. Similarly, the container can recognize the removal of the package by listening to BundleEvent.UNINSTALLED events and then it can unregister the corresponding descriptors. Additionally, application container must check the bundle registry for changes when they are started.

Receiving BundleEvent.INSTALLED events via a Synchronous Bundle Listener makes it possible for the application container to examine the package content during installation. A foreign application must not become available for execution unless it is started as a bundle. This mechanism allows foreign applications to be installed but not yet recognized as a foreign application.

120.4 Application Descriptor Resource

Applications' dependencies on services must be declared in the OSGI-INF/app/apps.xml resource. The XML file must use the http://www.osgi.org/xmlns/app/v1.0.0 name space. The preferred abbreviation is app. The XML schema definition can be found at *Component Description Schema* on page 469. The apps.xml file is optional if a foreign application does not require any dependencies.

The structure of the XML must conform to the description below.

```
<descriptor>        ::= <application> +
<application>       ::= <reference> *
```

120.4.1 Descriptor Element

The descriptor is the top level element. The descriptor element has no attributes.

120.4.2 Application Element

A JAR file can contain multiple application activators. The application element can therefore be repeated one or more times in the descriptor element.

The application element has the following attribute:

- class – The class attribute of the application element must contain the fully qualified name of the application's activator.

120.4.3 Reference Element

A reference element represents the applications use of a particular service. All services that an application uses must be declared in a reference element.

A reference element has the following attributes:

- name – A reference element is identified by a name. This name can be used in the locateService or locateService, see *Access to Services* on page 463. This name must be unique within an application element.

- interface – The fully qualified name of the interface or class that defines the selected service.
- policy – The choice of action when a bound services becomes unregistered while an application instance is running. It can have the following values:
  - static – If a bound service becomes unregistered, the application instance must be stopped but the corresponding Application Descriptor is still launchable.
  - dynamic – If a bound service becomes unregistered, the application can continue to run if the mandatory reference can still be satisfied by another service.
- cardinality – Defines the optionality of the reference. If it starts with a 0, an application can handle that the reference selects no service. That is, locateService method can return a null. If it starts with 1, the reference is mandatory and at least one service must be available before an application instance can be launched. The cardinality can have one of the following values:
  - 0..1 or 0..n – Optional reference
  - 1..1 or 1..n – Mandatory reference
- target – The optional target attribute of the element can be used to further narrow which services are acceptable for the application by providing an OSGi filter on the properties of the services.

120.4.4 Example XML

The following example is an application declaration for a MIDlet application that depends on the OSGi Log Service and another service:

```
<?xml version="1.0" ?>
<descriptor xmlns="http://www.osgi.org/xmlns/app/v1.0.0">
  <application class="com.acme.apps.SampleMidlet">
    <reference name="log" interface="org.osgi.service.log"/>
    <reference name="foo"
      interface="com.acme.service.FooService"
      policy="dynamic"
      cardinality="0..n" />
  </application>
</descriptor>
```

A similar example for an imaginary Xlet, with different dependencies:

```
<?xml version="1.0" encoding="UTF-8" ?>
<descriptor xmlns="http://www.osgi.org/xmlns/app/v1.0.0">
  <application class="com.acme.apps.SampleXlet">
    <reference name="log" interface="org.osgi.service.log"/>
    <reference name="bar"
          interface="com.acme.service.BarService"
          policy="static" cardinality="1..n" />
  </application>
</descriptor>
```

120.5 Component Description Schema

This XML Schema defines the component description grammar.

```
<xs:schema
    xmlns="http://www.osgi.org/xmlns/app/v1.0.0"
    xmlns:app="http://www.osgi.org/xmlns/app/v1.0.0"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
    targetNamespace="http://www.osgi.org/xmlns/app/v1.0.0"
    elementFormDefault="qualified"
    attributeFormDefault="unqualified"
    version="1.0.0">

   <xs:element name="descriptor" type="app:descriptorType">
      <xs:annotation>
         <xs:documentation>descriptor element encloses the applicaiton
            descriptors provided in a document</xs:documentation>
      </xs:annotation>
   </xs:element>

   <xs:complexType name="descriptorType">
      <xs:sequence>
         <xs:element name="application" type="app:applicationType"
            minOccurs="1" maxOccurs="unbounded"/>
      </xs:sequence>
   </xs:complexType>

   <xs:complexType name="applicationType">
      <xs:annotation>
         <xs:documentation>describes the service dependecies of
            an application</xs:documentation>
      </xs:annotation>
      <xs:sequence>
         <xs:element name="reference" minOccurs="0" maxOccurs="unbounded" type="referenceType"/>
      </xs:sequence>
      <xs:attribute name="class" type="xs:string"/>
   </xs:complexType>

   <xs:complexType name="referenceType">
      <xs:attribute name="name" type="xs:NMTOKEN" use="required"/>
      <xs:attribute name="interface" type="xs:string" use="required"/>
      <xs:attribute name="cardinality" default="1..1" use="optional" type="cardinalityType"/>
      <xs:attribute name="policy" use="optional" default="static" type="policyType"/>
      <xs:attribute name="target" type="xs:string" use="optional"/>
   </xs:complexType>

   <xs:simpleType name="cardinalityType">
      <xs:restriction base="xs:string">
        <xs:enumeration value="0..1"/>
        <xs:enumeration value="0..n"/>
        <xs:enumeration value="1..1"/>
        <xs:enumeration value="1..n"/>
      </xs:restriction>
   </xs:simpleType>

   <xs:simpleType name="policyType">
      <xs:restriction base="xs:string">
         <xs:enumeration value="static"/>
         <xs:enumeration value="dynamic"/>
      </xs:restriction>
   </xs:simpleType>
</xs:schema>
```

120.6 Security

120.6.1 Application Context Access

The getApplicationContext method provides access to the Application Context of a given applicaton activator. The application activator is therefore a capability; any party that has access to this object can potentially get its related Application Context and use it in intended ways.

A common pattern in small applications is to (ab)use the application activator class for all tasks, among them as service object. However, registering the application activator as a service will allow any party that can use that service to to use it as the parameter to the getApplicationContext method.

The Application Context must therefore be protected to not allow the registration of the application activator.

120.6.2 Signing

Application models can include the definition of a security model. For example, MIDP 2 defines a security model different from the standard Java 2 security model. If the foreign application model defines a security model different from Java 2 security, then it is the responsibility of the application container to implement this model and enforce it.

OSGi services are protected by Java 2 permissions. Applications wishing to use such services must have the appropriate permissions for those services.

Java 2 permissions are assigned during class loading based on the location of the code, the JAR signatures, and possibly based on other conditions, when using the Conditional Permission framework.

Signing is a very common technique to handle the granting of permissions. It requires that the JAR be signed according to the JAR Signing model. Therefore, OSGi-aware application packages should be signed by JAR signing. However, some foreign application models have alternative signing models in place. However, it is unlikely that this conflicts because JAR signing uses well defined separate files and manifest headers. If the foreign application model changes the JAR file outside the META-INF directory, then the signing according to the foreign application model must be performed before the standard JAR signing.

For example, in the case of MIDP signing and both models are used, the JAR signature should be put to the file first as it modifies the content of the file, and MIDP signing should be applied afterwards.

120.6.3 Permission Management

Applications that use OSGi services must have the corresponding Java 2 permissions granted. In order to simplify the policy management, and ensure that the overall device policy is consistent, application containers should not define separate policy management for each application model; rather they should use the existing OSGi policy management and express the complete security policy by the means of Java 2 permissions with the Conditional Permission Admin service. This way, policy administrator can define

the boundaries of the sandbox available for a particular application based on its location, signer or other condition. The application container is responsible for enforcing both the foreign application specific security mechanisms as well as the OSGi granted permissions.

Applications can package permissions as described in the Conditional Permission Admin, section 9.9 in the OSGi R4 Core specification. These permissions will restric the foreign's application permissions to maximally the permissions in this file scoped by the signer's permissions.

120.7 org.osgi.application

Foreign Application Package 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.application; version=1.0
```

120.7.1 Summary

- ApplicationContext - ApplicationContext is the access point for an OSGi-aware application to the features of the OSGi Service Platform. [p.471]
- ApplicationServiceEvent - An event from the Framework describing a service lifecycle change. [p.476]
- ApplicationServiceListener - An ApplicationServiceEvent listener. [p.477]
- Framework - Using this class, OSGi-aware applications can obtain their ApplicationContext[p.471] . [p.477]

120.7.2 public interface ApplicationContext

ApplicationContext is the access point for an OSGi-aware application to the features of the OSGi Service Platform. Each application instance will have its own ApplicationContext instance, which will not be reused after destorying the corresponding application instace.

Application instances can obtain their ApplicationContext using the Framework.getApplicationContext[p.477] method.

The lifecycle of an ApplicationContext instance is bound to the lifecycle of the corresponding application instance. The ApplicationContext becomes available when the application is started and it is invalidated when the application instance is stopped (i.e. the "stop" method of the application activator object returned). All method calls (except getApplicationId()[p.472] and getInstanceId()[p.472]) to an invalidated context object result an IllegalStateException.

See Also org.osgi.application.Framework[p.477]

120.7.2.1 public void addServiceListener(ApplicationServiceListener listener, String referenceName) throws IllegalArgumentException

listener The org.osgi.application.ApplicationServiceListener[p.477] to be added. It must not be null

referenceName the reference name of a service from the descriptor of the corresponding application. It must not be null.

- Adds the specified ApplicationServiceListener[p.477] object to this context application instance's list of listeners. The specified referenceName is a reference name specified in the descriptor of the corresponding application. The registered listener› will only receive the ApplicationServiceEvent[p.476] s realted to the referred service.

  If the listener was already added, calling this method will overwrite the previous registration.

Throws `IllegalStateException` – If this context application instance has stopped.

`NullPointerException` – If listener or referenceName is null

`IllegalArgumentException` – If there is no service in the application descriptor with the specified referenceName.

120.7.2.2 public void addServiceListener(ApplicationServiceListener listener, String[] referenceNames) throws IllegalArgumentException

listener The org.osgi.application.ApplicationServiceListener[p.477] to be added. It must not be null

referenceNames and array of service reference names from the descriptor of the corresponding application. It must not be null and it must not be empty.

- Adds the specified ApplicationServiceListener[p.477] object to this context application instance's list of listeners. The referenceNames parameter is an array of reference name specified in the descriptor of the corresponding application. The registered listener› will only receive the ApplicationServiceEvent[p.476] s realted to the referred services.

  If the listener was already added, calling this method will overwrite the previous registration.

Throws `IllegalStateException` – If this context application instance has stopped.

`NullPointerException` – If listener or referenceNames is null

`IllegalArgumentException` – If referenceNames array is empty or it contains unknown references

120.7.2.3 public String getApplicationId( )

- This method return the identifier of the correspondig application type. This identifier is the same for the different instances of the same application but it is different for different application type.

  Note: this method can safely be called on an invalid ApplicationContext as well.

Returns the identifier of the application type.

See Also

`org.osgi.service.application.ApplicationDescriptor.getApplicationId()`

120.7.2.4 public String getInstanceId( )

- This method returns the identifier of the corresponding application instace. This identifier is guarateed to be unique within the scope of the device. Note: this method can safely be called on an invalid ApplicationContext as well.

Returns the unique identifier of the corresponding application instance

See Also `org.osgi.service.application.ApplicationHandle.getInstanceId()`

120.7.2.5 public Map getServiceProperties(Object serviceObject)

serviceObject A service object the application is bound to. It must not be null.

- Application can query the service properties of a service object it is bound to. Application gets bound to a service object when it fisrt obtains a reference to the service by calling locateService or locateServices methods.

Returns The service properties associated with the specified service object.

Throws `NullPointerException` – if the specified serviceObject is null

`IllegalArgumentException` – if the application is not bound to the specified service object or it is not a service object at all.

`IllegalStateException` – If this context application instance has stopped.

120.7.2.6 public Map getStartupParameters( )

- Returns the startup parameters specified when calling the org.osgi.service.application.ApplicationDescriptor.launch method.

  Startup arguments can be specified as name, value pairs. The name must be of type java.lang.String, which must not be null or empty java.lang.String (“”), the value can be any object including null.

Returns a java.util.Map containing the startup arguments. It can be null.

Throws `IllegalStateException` – If this context application instance has stopped.

120.7.2.7 public Object locateService(String referenceName)

referenceName The name of a reference as specified in a reference element in this context applications’s description. It must not be null

- This method returns the service object for the specified referenceName. 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 org.osgi.framework.Constants.SERVICE_RANKING property) is returned. If there is a tie in ranking, the service with the lowest service ID (as specified in its org.osgi.framework.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 `NullPointerException` – If referenceName is null.

`IllegalArgumentException` – If there is no service in the application descriptor with the specified referenceName.

`IllegalStateException` – If this context application instance has stopped.

120.7.2.8 public Object[] locateServices(String referenceName)

referenceName The name of a reference as specified in a reference element in this context applications's description. It must not be null.

- This method returns the service objects for the specified referenceName.

Returns An array of 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 `NullPointerException` – If referenceName is null.

`IllegalArgumentException` – If there is no service in the application descriptor with the specified referenceName.

`IllegalStateException` – If this context application instance has stopped.

120.7.2.9 public ServiceRegistration registerService(String[] clazzes, Object service, Dictionary properties)

clazzes The class names under which the service can be located. The class names in this array will be stored in the service's properties under the key org.osgi.framework.Constants.OBJECTCLASS. This parameter must not be null.

service The service object or a ServiceFactory object.

properties The properties for this service. The keys in the properties object must all be String objects. See org.osgi.framework.Constants for a list of standard service property keys. Changes should not be made to this object after calling this method. To update the service's properties the org.osgi.framework.ServiceRegistration.setProperties method must be called. The set of properties may be null if the service has no properties.

- Registers the specified service object with the specified properties under the specified class names into the Framework. A org.osgi.framework.ServiceRegistration object is returned. The org.osgi.framework.ServiceRegistration object is for the private use of the application registering the service and should not be shared with other applications. The registering application is defined to be the context application. Bundles can locate the service by using either the org.osgi.framework.BundleContext.getServiceReferences or org.osgi.framework.BundleContext.getServiceReference method. Other applications can locate this service by using locateService(String)[p.473] or locateServices(String)[p.473] method, if they declared their dependece on the registered service.

  An application can register a service object that implements the org.osgi.framework.ServiceFactory interface to have more flexibility in providing service objects to other applications or bundles.

  The following steps are required to register a service:

  1 If service is not a ServiceFactory, an IllegalArgumentException is thrown if service is not an instanceof all the classes named.
  2 The Framework adds these service properties to the specified Dictionary (which may be null): a property named org.osgi.framework.Constants.SERVICE_ID identifying the registration number of the service and a property named org.osgi.framework.Constants.OBJECTCLASS containing all the specified classes. If any of these properties have already been specified by the registering bundle, their values will be overwritten by the Framework.

3 The service is added to the Framework service registry and may now be used by others.
4 A service event of type org.osgi.framework.ServiceEvent.REGISTERED is fired. This event triggers the corresponding ApplicationServiceEvent[p.476] to be delivered to the applications that registered the appropriate listener.
5 A ServiceRegistration object for this registration is returned.

Returns A org.osgi.framework.ServiceRegistration object for use by the application registering the service to update the service's properties or to unregister the service.

Throws IllegalArgumentException – If one of the following is true:
service is null.
service is not a ServiceFactory object and is not an instance of all the named classes in clazzes.
properties contains case variants of the same key name.

NullPointerException – if clazzes is null

SecurityException – If the caller does not have the ServicePermission to register the service for all the named classes and the Java Runtime Environment supports permissions.

IllegalStateException – If this ApplicationContext is no longer valid.

See Also

org.osgi.framework.BundleContext.registerService(java.lang.String[], java.lang.Object, java.util.Dictionary), org.osgi.framework.ServiceRegistration, org.osgi.framework.ServiceFactory

120.7.2.10 public ServiceRegistration registerService(String clazz, Object service, Dictionary properties)

clazz The class name under which the service can be located. It must not be null

service The service object or a ServiceFactory object.

properties The properties for this service.

□ Registers the specified service object with the specified properties under the specified class name with the Framework.

This method is otherwise identical to registerService(java.lang.String[], java.lang.Object, java.util.Dictionary)[p.474] and is provided as a convenience when service will only be registered under a single class name. Note that even in this case the value of the service's Constants.OBJECTCLASS property will be an array of strings, rather than just a single string.

Returns A ServiceRegistration object for use by the application registering the service to update the service's properties or to unregister the service.

Throws IllegalArgumentException – If one of the following is true:
service is null.
service is not a ServiceFactory object and is not an instance of the named class in clazz.
properties contains case variants of the same key name.

NullPointerException – if clazz is null

SecurityException – If the caller does not have the ServicePermission to register the service the named class and the Java Runtime Environment supports permissions.

IllegalStateException – If this ApplicationContext is no longer valid.

See Also registerService(java.lang.String[], java.lang.Object, java.util.Dictionary)[p.474]

120.7.2.11 public void removeServiceListener(ApplicationServiceListener listener)

listener The org.osgi.application.ApplicationServiceListener[p.477] object to be removed.

- Removes the specified org.osgi.application.ApplicationServiceListener[p.477] object from this context application instances's list of listeners.

  If listener is not contained in this context application instance's list of listeners, this method does nothing.

Throws IllegalStateException – If this context application instance has stopped.

120.7.3 public class ApplicationServiceEvent extends ServiceEvent

An event from the Framework describing a service lifecycle change.

ApplicationServiceEvent objects are delivered to a ApplicationServiceListener objects when a change occurs in this service's lifecycle. The delivery of an ApplicationServiceEvent is always triggered by a org.osgi.framework.ServiceEvent. ApplicationServiceEvent extends the content of ServiceEvent with the service object the event is referring to as applications has no means to find the corresponding service object for a org.osgi.framework.ServiceReference. A type code is used to identify the event type for future extendability. The available type codes are defined in org.osgi.framework.ServiceEvent.

OSGi Alliance reserves the right to extend the set of types.

See Also org.osgi.framework.ServiceEvent, ApplicationServiceListener[p.477]

120.7.3.1 public ApplicationServiceEvent(int type, ServiceReference reference, Object serviceObject)

type The event type. Available type codes are defines in org.osgi.framework.ServiceEvent

reference A ServiceReference object to the service that had a lifecycle change. This reference will be used as the source in the java.util.EventObject baseclass, therefore, it must not be null.

serviceObject The service object bound to this application instance. It can be null if this application is not bound to this service yet.

- Creates a new application service event object.

Throws IllegalArgumentException – if the specified reference is null.

120.7.3.2 public Object getServiceObject( )

□ This method returns the service object of this service bound to the listener application instace. A service object becomes bound to the application when it first obtains a service object reference to that service by calling the ApplicationContext.locateService or locateServices methods. If the application is not bound to the service yet, this method returns null.

Returns the service object bound to the listener application or null if it isn't bound to this service yet.

120.7.4 public interface ApplicationServiceListener extends EventListener

An ApplicationServiceEvent listener. When a ServiceEvent is fired, it is converted to an ApplictionServiceEvent and it is synchronously delivered to an ApplicationServiceListener.

ApplicationServiceListener is a listener interface that may be implemented by an application developer.

An ApplicationServiceListener object is registered with the Framework using the ApplicationContext.addServiceListener method. ApplicationServiceListener objects are called with an ApplicationServiceEvent object when a service is registered, modified, or is in the process of unregistering.

ApplicationServiceEvent object delivery to ApplicationServiceListener objects is filtered by the filter specified when the listener was registered. If the Java Runtime Environment supports permissions, then additional filtering is done. ApplicationServiceEvent objects are only delivered to the listener if the application which defines the listener object's class has the appropriate ServicePermission to get the service using at least one of the named classes the service was registered under, and the application specified its dependece on the corresponding service in the application metadata.

ApplicationServiceEvent object delivery to ApplicationServiceListener objects is further filtered according to package sources as defined in `ServiceReference.isAssignableTo(Bundle, String)`.

See Also `ApplicationServiceEvent`[p.476], `ServicePermission`

120.7.4.1 public void serviceChanged(ApplicationServiceEvent event)

event The ApplicationServiceEvent object.

□ Receives notification that a service has had a lifecycle change.

120.7.5 public final class Framework

Using this class, OSGi-aware applications can obtain their `ApplicationContext`[p.471].

120.7.5.1 public static ApplicationContext getApplicationContext(Object applicationInstance)

applicationInstance is the activator object of an application instance

- This method needs an argument, an object that represents the application instance. An application consists of a set of object, however there is a single object, which is used by the corresponding application container to manage the lifecycle on the application instance. The lifetime of this object equals the lifetime of the application instance; therefore, it is suitable to represent the instance.

  The returned ApplicationContext[p.471] object is singleton for the specified application instance. Subsequent calls to this method with the same application instance must return the same context object

Returns the ApplicationContext[p.471] of the specified application instance.

Throws NullPointerException – If applicationInstance is null

IllegalArgumentException – if called with an object that is not the activator object of an application.

120.8 References

[1] *OSGi Core Specifications*
http://www.osgi.org/download

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

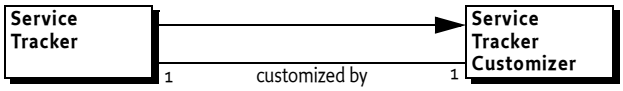
The fundamental tasks of a ServiceTracker object are:

- 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 701.1 *Class diagram of org.osgi.util.tracker*



701.1.4 Prerequisites

This specification requires OSGi Framework version 1.1 or higher because the Service Tracker 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 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

Service Tracker Package 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.483]
- ServiceTrackerCustomizer - The ServiceTrackerCustomizer interface allows a ServiceTracker object to customize the service objects that are tracked. [p.488]

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 against which this ServiceTracker object is tracking.

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.488]

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.488]

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.487]

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 accessibile 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.488]

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 indefinately.

- 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 it 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 [4] *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

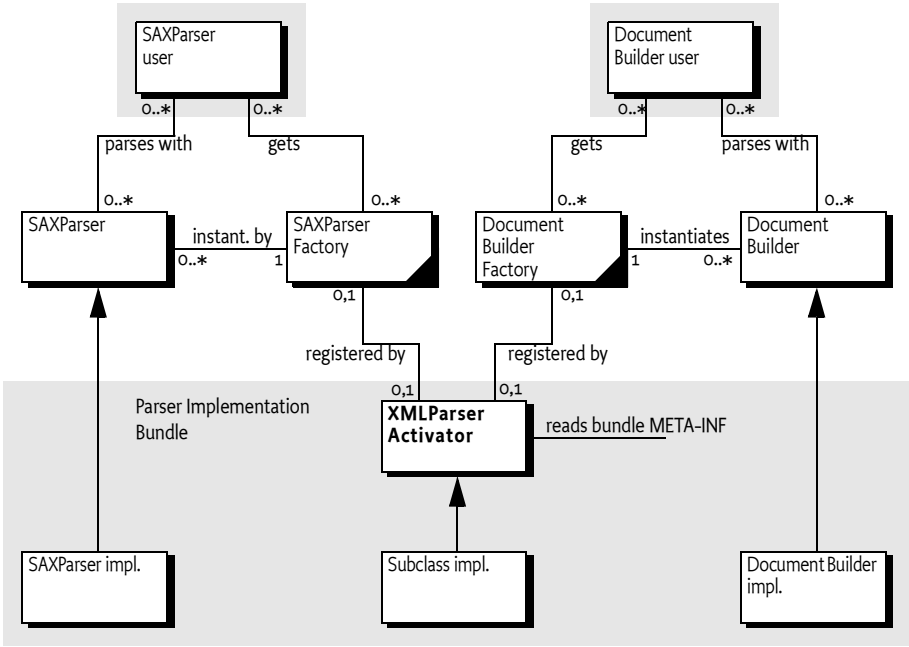
702.1.1 Essentials

- *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 702.1 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 [4] *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 [5] *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 493, 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 [4] *JAXP* for the exact version dependencies.

This specification is related to related packages as defined in the JAXP 1.1 document. Table 702.1 contains the expected minimum versions.

Table 702.1 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.xsml.sax.ext	1.0
org.w3c.dom	2.0

The Xerces project from the Apache group, [6] *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

XML Parser Package 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.xml; 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.498])
- javax.xml.parsers.DocumentBuilderFactory(DOMFACTORYNAME[p.498])

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.498] - indicates if this factory supports validating parsers. It's value is a Boolean.
- PARSER_NAMESPACEAWARE[p.498] - indicates if this factory supports namespace aware parsers It's 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

[1] *XML*
http://www.w3.org/XML

[2] *SAX*
http://www.saxproject.org/

[3] *DOM Java Language Binding*
http://www.w3.org/TR/REC-DOM-Level-1/java-language-binding.html

[4] *JAXP*
http://java.sun.com/xml/jaxp

[5] *JAR File specification, services directory*
http://java.sun.com/j2se/1.4/docs/guide/jar/jar.html

[6] *Xerces 2 Java Parser*
http://xml.apache.org/xerces2-j

End Of Document